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REPORT NO. E-0067-RT/2

FINAL TECHNICAL REPORT

40-FT-DIAMETER RINGSAIL PARACHUTE

PLANETARY ENTRY PARACHUTE PROGRAM

ABSTRACT

The Planetary Entry Parachute Program 40-foot nominal diameter ringsail parachute design is analyzed with respect to material strengths, shock loading, and material stress analysis. This report summarizes calculations on which the design is based, material and joint test data, stress analysis procedures, and system weight and center of gravity location calculations. A materials properties section is also included and basic parachute system configuration and dimensions are defined.

Report No. E-0067-RT/2

Final Technical Report

40-ft-diameter Ringsail Parachute

Planetary Entry Parachute Program

Submitted to:

Martin Marietta Corp.

Contract No. MC7-709025

Prepared by:

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Report No. E-0067-RT/2

FINAL TECHNICAL REPORT
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PLANETARY ENTRY PARACHUTE PROGRAM

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ERRATA

Location	Error	Correction
List of Illustrations	no page number	page no. v
List of Tables	no page number	page no. vi
	10-1....4-ft....	10-1....40-ft....
P. 31	$3.142^{\text{in.}} = y$	3.142 in. = y
	$X = \frac{33-31/64}{2} = {}^{2}{}_{\sin}{}^{5°}$	$X = \frac{33-31/64}{2} = 2\sin 5°$
P. 48 Last line in Table 10-2	31.474	31.474*
P. 51	W_r	W_R
P. 53 Equation (11-6)	$.......r^4\{\pi.......$	$.......r^4\pi\{.......$
P. 54 Equation (11-13)	$....r^3[\frac{\pi}{4}\sin^2\psi....$	$.....r^3[\sin^2\psi.....$
P. 55 Equation (11-17)	.... = .56 ×	.... = .173 × ....
Equation (11-19)	$...\frac{7}{12}\cos^2\psi......$	$...\frac{7}{12}\cos^2\alpha......$

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1.0 INTRODUCTION

This report is submitted by Pioneer Parachute Company in accordance with paragraph 1.17 of Section B of the Work Statement contained in Martin Company Procurement Specification No. LY 810507, dated February, 1967.

The subject parachutes were designed and manufactured under Martin-Marietta Corporation Contract No. MC7-709025, dated March 1967.

2.0 DESIGN SPECIFICATION

The parachute system described in Martin Company Procurement Specification No. LY 810507 is for use in the rocket-launch phase of the Planetary Entry Parachute Program.

The system as specified, consists of

(a) parachute,

(b) riser, bridle, fittings,

(c) deployment bag,

(d) rereefing components, and

(e) miscellaneous supporting hardware.

2.1 Parachute

The specified parachute is a 40-ft-nominal-diameter ringsail having the same basic geometric shape and porosity proportions as the 30-ft ringsail parachute, Pioneer Dwg. No. 1.119. Cloth porosity is disregarded. The suspension-line length is no greater than the nominal parachute diameter. The color of the canopy is natural with a 6-in.-wide blue stripe on the inside of the canopy from the vent to the bottom of the skirt and around the bottom of the skirt. The substance used for this stripe will not structurally degrade or impair the flexibility of the canopy material.

2.2 Riser System, Deployment Bag and Rereefing Components

Risers, bridles, and deployment bags are in accordance with LRC Dwg. LC-151819. The fittings shown on the drawing were supplied by Martin Company. The parachute as supplied is packed for service in a deployment bag compatible with the Irving Type I mortar. The specified packed density is 40 ± 2 lb/ft^3. A balsawood filler block is installed in the deployment bag prior to packing. Its size is such as achieves the required pack density.

A rereefing system is included in the specified parachute system to reduce the drag area of the parachute and to achieve a terminal velocity of 40 ft/sec at 4000 ft.

The rereefing mechanism is to be installed by Martin Company.

2.3 Deployment Conditions and Weight

The specified nominal payload weight is 205 lb, and the weight of the parachute is 30 to 35 lb, excluding the riser system but including the deployment bag.

The parachute is capable of opening without structural failure at mach 1.6, dynamic pressure of 12 lb/ft^2, velocity of 1650 ft/sec, and a mortar ejection velocity of 120 ft/sec.

2.4 Miscellaneous Requirements

The complete parachute system, as specified, is capable of deployment and of sustaining opening loads without structural failure after being subjected to 125°C for 120 hr while packed. In addition, the system is shipped in a reusable container, to prevent the parachute pack from growing in size during shipping and storage. This container and any packing material used also is able to withstand the sterilization process.

The specified margin of safety of structural loads is positive in all cases.

Each component part that can be disconnected from the system has an identifying serial number.

3.0 DESIGN DATA

The parachute system was designed to meet the requirements given in Section 2.0 and consists of a parachute with attached riser, an intermediate riser, a vehicle-attachment riser (or bridle), and a deployment bag.

The secondary riser and reefing lines were considered part of the parachute assembly. The parachute is a 40-ft-nominal-diameter ringsail with 36 gores; the 40-ft suspension lines were sewn directly onto a four-legged riser.

The basic shape of the uninflated parachute is approximately a quarter-sphere. The canopy has 11 rings and sails, of which sail 9 is omitted to form a 14-in. gap. The total area of the canopy is 1257 ft^2. Using a C_D of 0.60, the estimated drag area for the chute is 754 ft^2.

The total geometric porosity (λ_g) is 15%. The geometric porosity of the crown area (λ_{g_c}) is 2.27%.

4.0 GORE LAYOUT AND PARACHUTE CONFIGURATION

The parachute type, diameter, and geometric porosity were specified by Martin Company Procurement Specification No. LY 810507. The parachute requested was to be a ringsail type with 40-ft nominal diameter and 15% geometric porosity. Pioneer selected a 36-gore configuration as the optimum.

The area S_o of the canopy was calculated from the equation

$$S_o = \frac{\pi}{4} \times D_o^2 = \frac{\pi}{4} \times 40^2 = 1256.64 \text{ ft}^2,$$

where D_o is the nominal diameter. The stipulated ringsail parameters were then applied to determine the diameter of the sphere on whose surface the required canopy area would subtend a 108° vertex angle (see Fig. 4-1).

4.1 Basic Gore Geometry

Ringsail parachutes have typically presented many problems arising from infolding at the skirt caused by the excess material required for fullness. To eliminate such excess, and thereby to minimize infolding, it was decided to increase the above-calculated canopy area in the ratio of 38:36 and to recalculate the sphere diameter accordingly. The gore parameters were then calculated as if the parachute were to have 38 gores. However, to keep to the proper canopy area, only 36 gores were assigned to each parachute.

Hence, the area used to calculate the radius of the sphere was

$$A = 1256.64 \times \frac{38}{36} = 1326.45 \text{ ft}^2.$$

Referring again to Fig. 4-1, we can see that

$$A = 1326.45 = \pi \left(\frac{C^2}{4} + h^2\right),$$

and we compute as follows.

$$h = 0.412R;$$

$$\tan 54° = \frac{C/2}{0.588R},$$

$$C = 1.176R \times \tan 54° = 1.176R \times 1.3764$$
$$= 1.61865R.$$

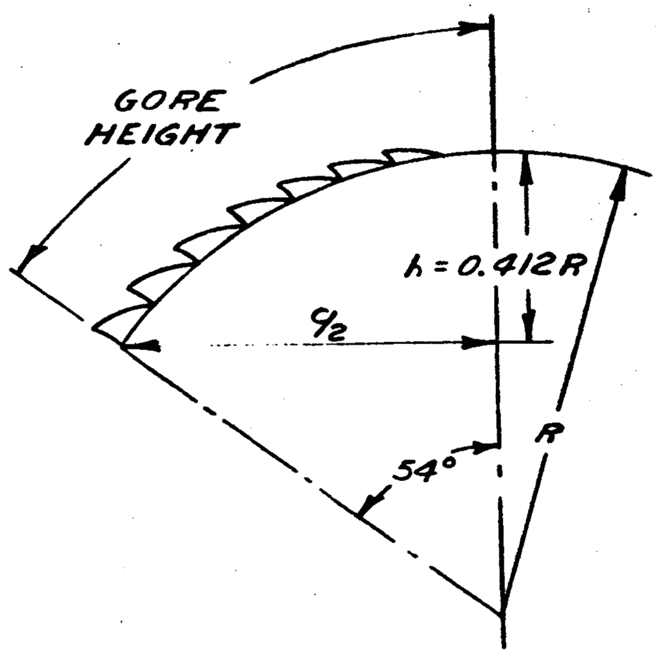


Fig. 4-1. Basic ringsail geometry.

Substituting these values of C and h, we find

$$1326.45 = \pi \left[\frac{(1.61865R)^2}{4} + (0.412R)^2 \right] ;$$

$$R^2 = \frac{1326.45 \times 4}{\pi \times 3.29898} = 511.94266$$

$$R = 22.6261 \text{ ft.}$$

$$\text{Total height of gore} = 22.6261 \times 12 \times \frac{54 \times \pi}{180}$$

$$= 255.90 \text{ in.}$$

The method of calculating the basic gore dimensions and the resultant dimensions are illustrated in Fig. 4-2.

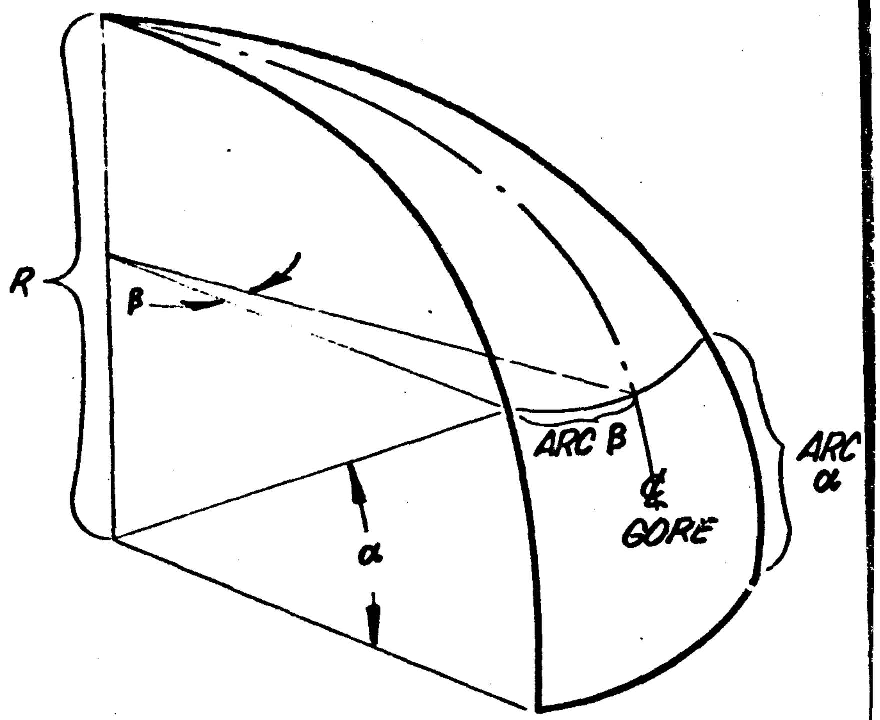
Following calculation of the basic gore dimensions, the number of sails was determined. It was decided to use half-width cloth for the sails since the cloth was 45 in. wide. This resulted in 11 sails; the upper four were actually rings separated by slots. The widths of the four slots, from the top down, were 4, 3, 2, and 1 in., respectively. To achieve the required 15% minimum geometric porosity, the 9th sail was omitted. All sails were 21.5 in. high (finished) except ring 1, which was 20 in. high, and sail 11, which was 21 in. high. Since the distance up the center of the gore was known for the leading and trailing edges of each sail (or ring), it was possible to calculate the gore width at all necessary points by straight-line interpolation between the closest two values taken from Fig. 4-2.

After the basic ring and sail dimensions were calculated, fullness was added. The basic ring and sail dimensions, with and without fullness, are shown in Table 4-1, and the fullness allowed is charted in Fig. 4-3.

No. of gores	Area S_o, ft^2
36	1257
38	1326

$R = 22.6261$ ft
$= 255.90$ in.

$$\beta = \frac{360}{2 \times 38} = 4.73684°$$
$= 0.08267$ radians



α deg	cos α	α, rad	Arc α, in.*	Arc α − 170.59, in.	Arc β, in.†	2 arc β, in.
90	0	1.5708	426.49	255.90	0	0
86°00.7'	0.0700	1.5012	407.59	237.00	1.571	3.142
85	0.0872	1.4835	402.79	232.20	1.957	3.914
80	0.1737	1.3963	379.11	208.52	3.899	7.798
75	0.2588	1.3090	355.41	184.82	5.809	11.618
70	0.3420	1.2217	331.70	161.11	7.676	15.353
65	0.4226	1.1345	308.03	137.44	9.486	18.971
60	0.5000	1.0472	284.33	113.74	11.223	22.446
55	0.5736	0.9599	260.62	90.03	12.875	25.750
50	0.6428	0.8727	236.95	66.36	14.428	28.856
45	0.7071	0.7854	213.24	42.65	15.871	31.743
40	0.7660	0.6981	189.54	18.95	17.193	34.387
36	0.8090	0.6283	170.59	0	18.159	36.317

*Arc α = Rα, where R is in inches and α is in radians.
†Arc β = Rβ cos α, where R is in inches and β is in radians.

Figure 4-2. Basic gore dimensions for the 40-ft ringsail.

TABLE 4-1
SAIL DIMENSIONS FOR THE 40-ft RINGSAIL

Sail no.	Lower edge				Upper edge			
	Height up gore, in.	Width, in.		Fullness, %	Height up gore, in.	Width, in.		Fullness, %
		Without fullness	With fullness			Without fullness	With fullness	
11	0	36.317	39.222	8.0	21.0	34.158	34.158	
10	21.0	34.158	36.583	7.1	42.5	31.760	31.760	0
9	O M I T T E D							
8	56.5	30.057	31.620	5.2	78.0	27.329	27.329	0
7	78.0	27.329	28.504	4.3	99.5	24.430	24.430	0
6	99.5	24.430	25.236	3.3	121.0	21.382	21.532	0.7
5	121.0	21.382	21.895	2.4	142.5	18.198	18.453	1.4
4	143.5	18.045	18.298	1.4	165.0	14.740	14.946	1.4
3	167.0	14.425	14.627	1.4	188.5	11.025	11.179	1.4
2	191.5	10.541	10.689	1.4	213.0	7.063	7.162	1.4
1	217.0	6.407	6.497	1.4	237.0	3.142	3.142	0

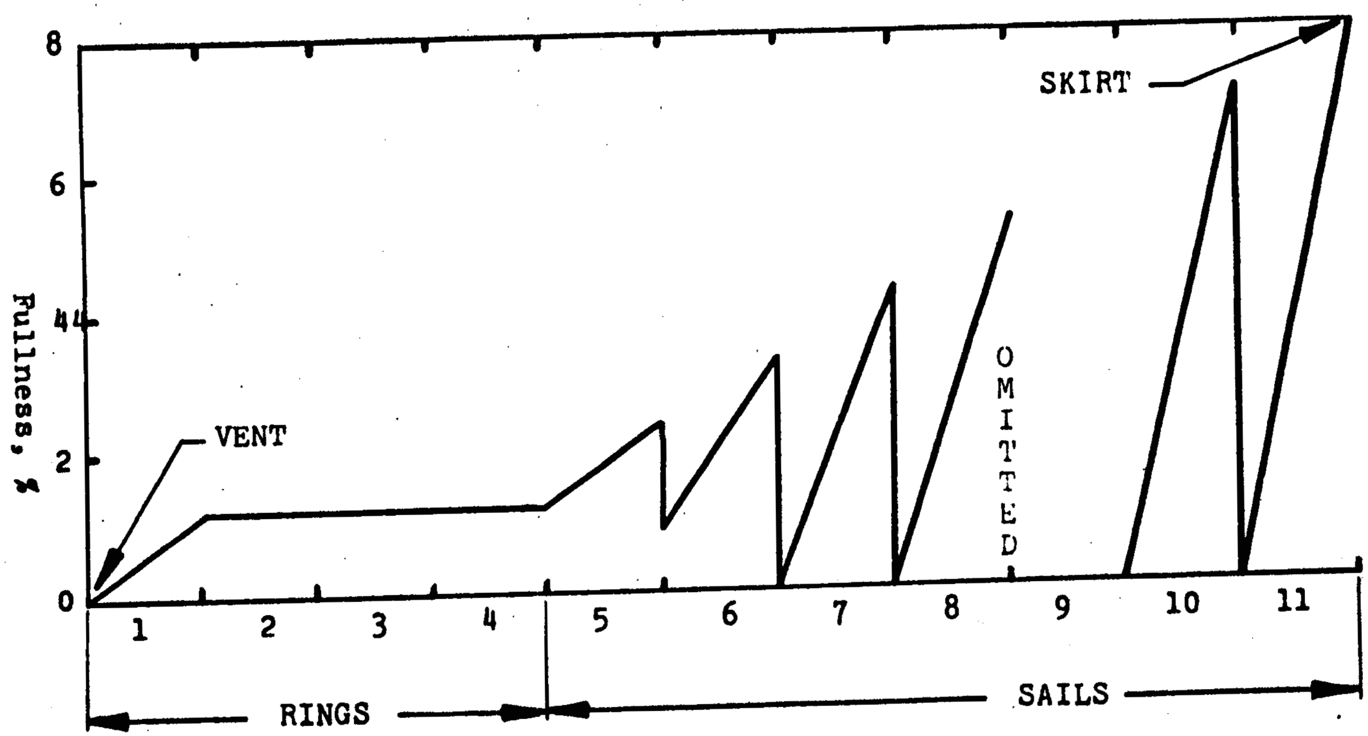


Fig. 4-3. Fullness allowed on the 40-ft ringsail.

Next, the pattern dimensions (including seam allowances) were calculated. The final pattern dimensions are summarized in Fig. 4-4.

4.2 Geometric Porosity

This section presents the calculations required to yield a 40-ft-dia. ringsail parachute with a geometric porosity of 15%, as established by NASA. The method used is to determine the total area of a single gore (from the basic gore dimensions calculated by the method described in section 4.1) and then to compare that area with the total open area in the gore.

To determine the total area of a gore, we assume that a gore comprises a number of trapezoids and a terminal triangle (at the vent end). Figure 4-5 (not to scale) illustrates how this assumption can be applied to the 40-ft parachute. All the dimensions shown are taken directly from the geometry calculations in Section 4.1 and are in inches.

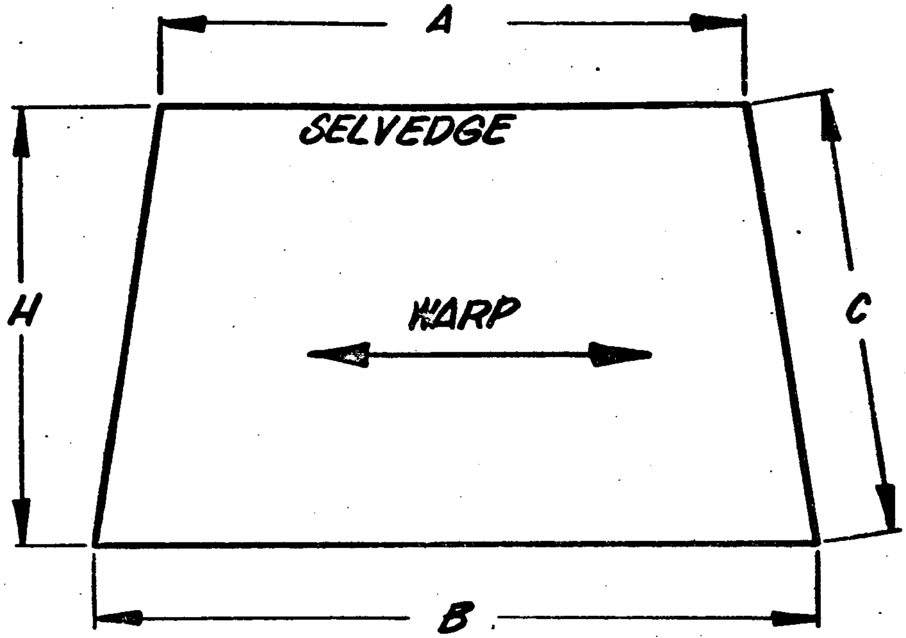
The area of each trapezoid and the area of the triangle were calculated and summed to yield the total gore area.

The open area was calculated after the number of sails, their size, and the percentage of fullness allowed had been determined (see Section 4.1). The open area can be thought of as comprising four types:

(a) the vent (the area covered by the vent lines must be subtracted from the total),

(b) the slots in the crown area (assumed trapezoidal),

(c) the 9th sail (which will be omitted, leaving an assumedly trapezoidal gap surmounted by a sail scoop), and



Sail	H	A	B	C
1	22.5	5.345	9.008	22.574
2	22.5	9.520	13.263	22.578
3	22.5	13.594	17.252	22.574
4	22.5	17.413	20.970	22.570
5	22.5	20.969	24.622	22.574
6	22.5	24.091	28.021	22.586
7	22.5	27.032	31.355	22.604
8	22.5	29.974	34.527	22.615
9	O M I T T E D			
10	22.5	34.469	39.587	22.645
11	22.5	36.902	42.403	22.668

Figure 4-4. Ring and sail patterns for the 40-ft ringsail. Dimensions are given in inches.

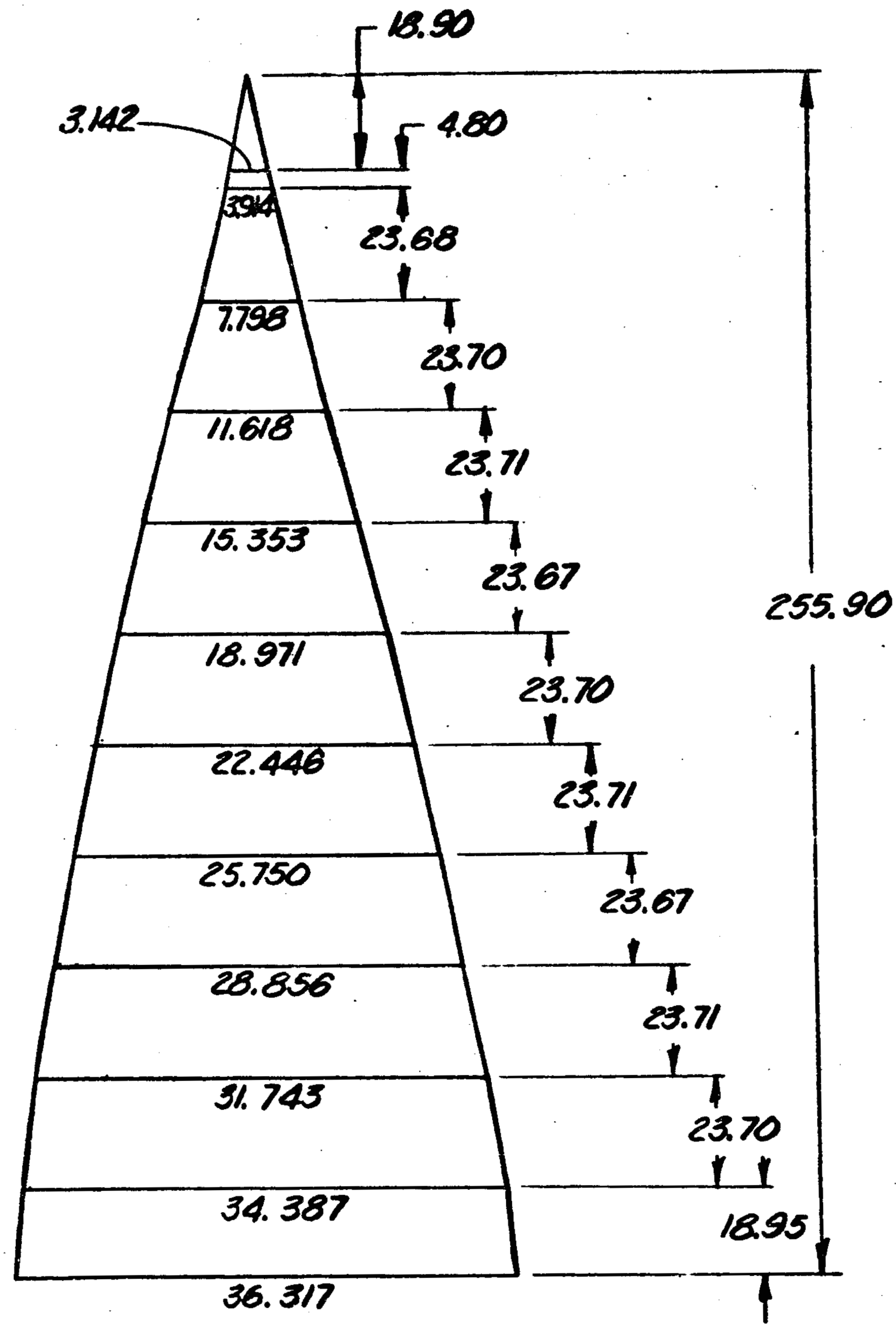


Fig. 4-5. Basic gore of the 40-ft ringsail, for porosity calculations.

(d) the sail scoops (treated here as triangles). In flight, the sail scoops will probably assume crescent shapes but may at any given time resemble anything from a thin crescent to an ellipse. Seventy-five percent of the triangular shape is taken as a reasonable approximation. Possible and assumed shapes are illustrated in Fig. 4-6.

Geometric porosity λ_g (in percent) is calculated from the formula

$$\lambda_g = \frac{(\text{total open area}) \times 100}{(\text{total area})}. \qquad (4\text{-}1)$$

The calculations made for the 40-ft-dia. ringsail parachute follow.

<u>Total area of one gore</u> (see Fig. 4-5 for dimension references).

$$(35.352 \times 18.95) + 23.71\,(30.2995 + 24.098 + 13.4855) + 23.70\,(33.065 + 20.7085 + 9.708) + 23.67\,(27.303 + 17.162) + (23.68 \times 5.856) + (3.528 \times 4.80) + (1.571 \times 18.90) = 5021.7208 \text{ in}^2.$$

Total open area of one gore = (a) + (b) + (c) + (d), where all dimensions are obtained from the ring and sail dimensions calculated in Section 4.1:

(a) Vent.

$$\tfrac{1}{2}\,[(\text{base}) - (\text{vent-line overlap})] \times [(\text{alt.}) - (\text{vent-line overlap})]$$

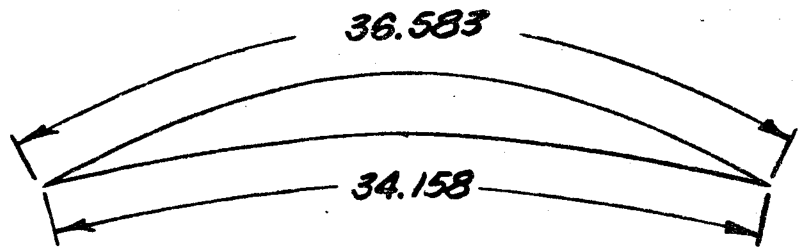
$$= \tfrac{1}{2}\,(3.142 - 0.75) \times (18.90 - 1.0)$$

$$= 21.4084 \text{ in}^2.$$

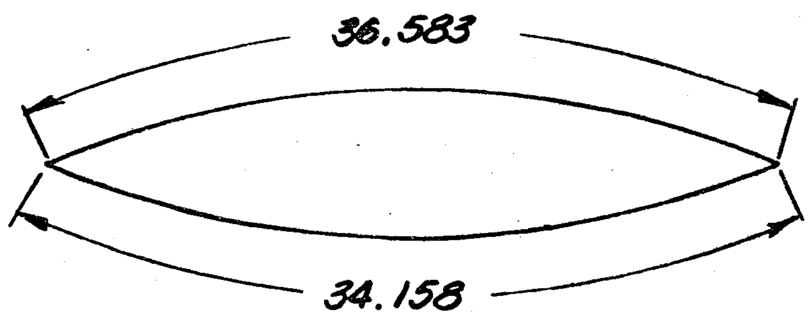
(b) Slots (less radial-tape blockage)

$$[1 \times (18.3755 - 0.75)] + [2 \times (14.7865 - 0.75)] + [3 \times (10.934 - 0.75)] + [4 \times (6.8295 - 0.75)]$$

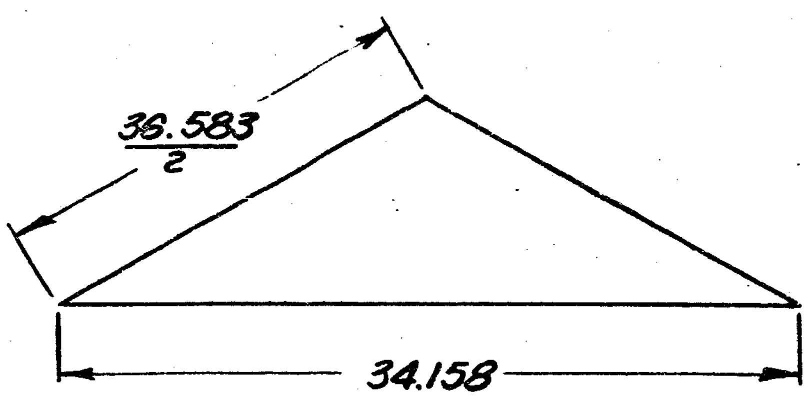
$$= 92.5685 \text{ in}^2.$$



(a) Probable actual shape



(b) Possible Shape



(c) 75% of area of this shape assumed for porosity calculations

Fig. 4-6. Scoop shape. All dimensions are in inches and are taken from Section 4.1. They are for the trailing edge of sail 11 and the leading edge of sail 10.

Slots + vent = 113.9769 in^2;

λ_{g_c} (crown area geometric porosity) = $\frac{113.9769 \times 100}{5021.7208}$

= 2.27%. Figure 4-7 of this report indicates that the crown-area geometric porosity for a 40-ft-D_o ringsail should be approximately 2.4%.

(c) Omitted 9th sail less radial-tape blockage (see Fig. 4-8).

$$x_1 = [15.435^2 - 14.6535^2]^{1/2} = 4.84914;$$

$$\text{area}_1 = 14.00 \times 1/2(29.307 + 31.010) + 3/4(14.6535 \times 4.84914) = 475.5116\ in^2.$$

(d) Sail scoops less radial-tape blockage (see Fig. 4-9).

$$x_2 = [17.9165^2 - 16.704^2]^{1/2} = 6.47899;$$

$$\text{area}_2 = 3/4(16.704 \times 6.47899) = 81.1687\ in^2.$$

$$x_3 = [13.877^2 - 13.2895^2]^{1/2} = 3.99503;$$

$$\text{area}_3 = 3/4(13.2895 \times 3.99503) = 39.8189\ in^2.$$

$$x_4 = [12.243^2 - 11.840^2]^{1/2} = 3.11535;$$

$$\text{area}_4 = 3/4(11.840 \times 3.11535) = 27.6643\ in^2.$$

$$x_5 = [10.5725^2 - 10.391^2]^{1/2} = 1.95060;$$

$$\text{area}_5 = 3/4(10.391 \times 1.95060) =$$

Area of scoops = 163.8534 in^2.

Total open area:

$$21.4084 + 92.5685 + 475.5116 + 163.8534 = 753.3419\ in^2.$$

Hence, from Eq. (4-1), the percentage of total open area, λ_g, is

$$\frac{753.3419 \times 100}{5021.7208} = 15.00\% \qquad \text{(see Fig. 4-10).}$$

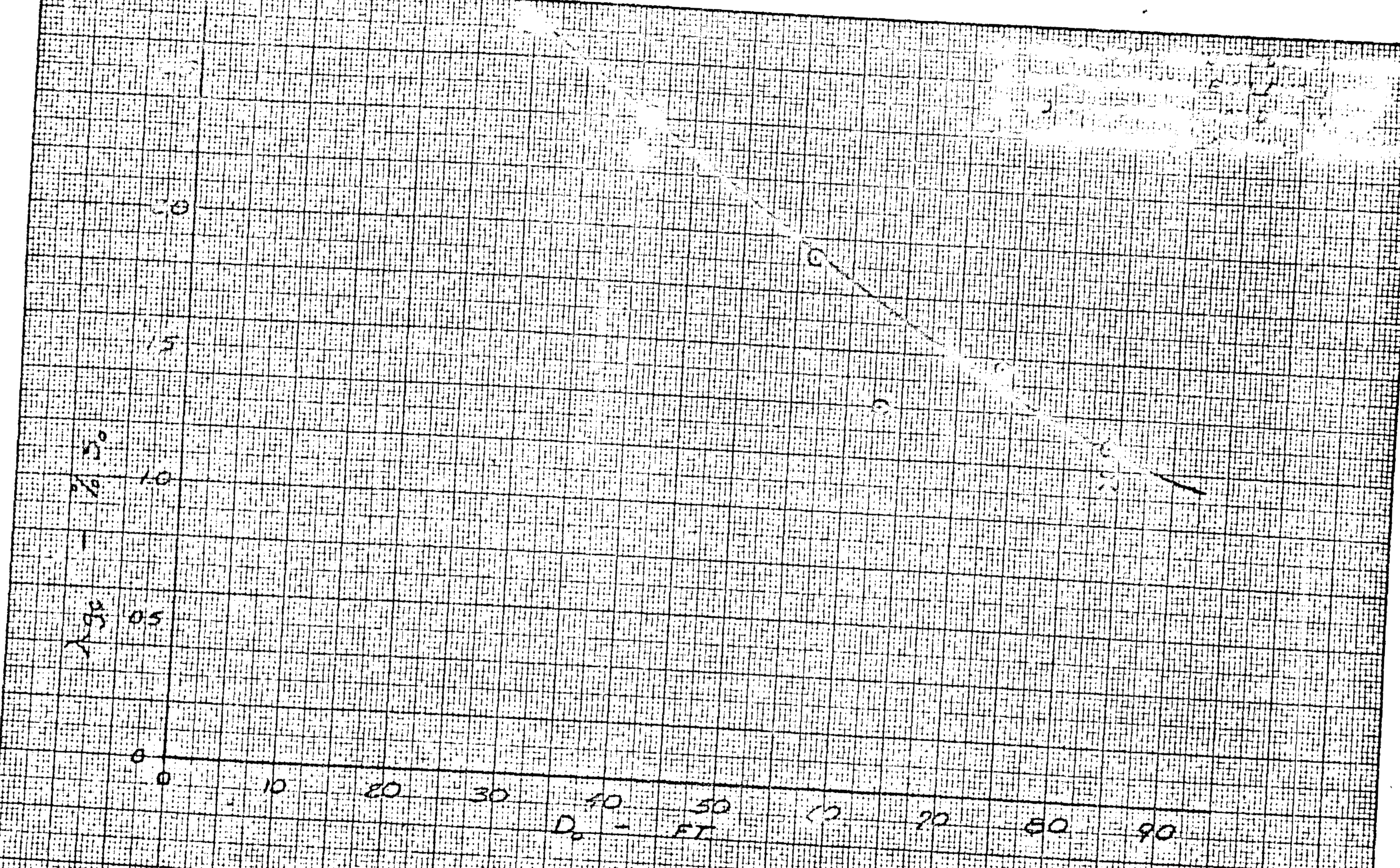


FIGURE 4-7 - GEOMETRIC POROSITY OF CROWN AREA VS PARACHUTE DIAMETER FOR RINGSAIL PARACHUTES

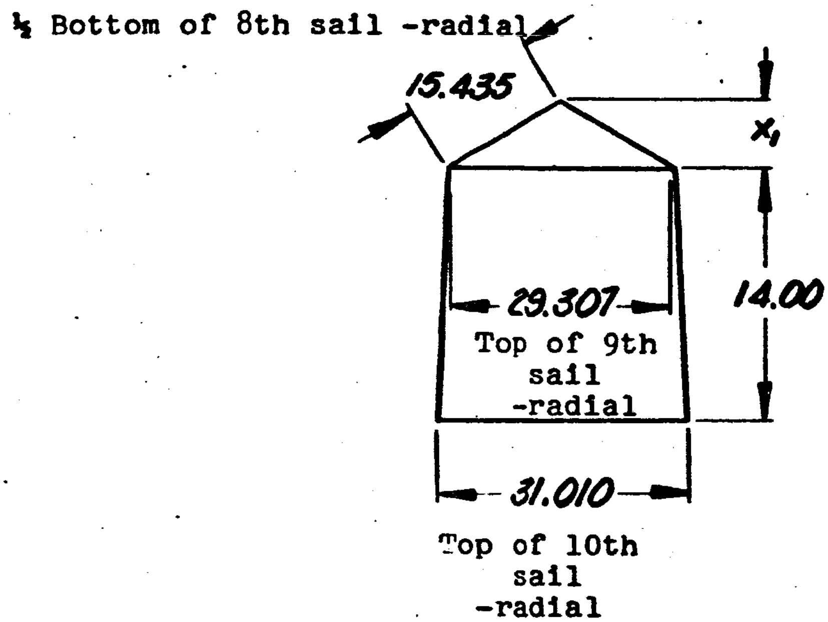


Fig. 4-8. Geometry of omitted 9th sail.

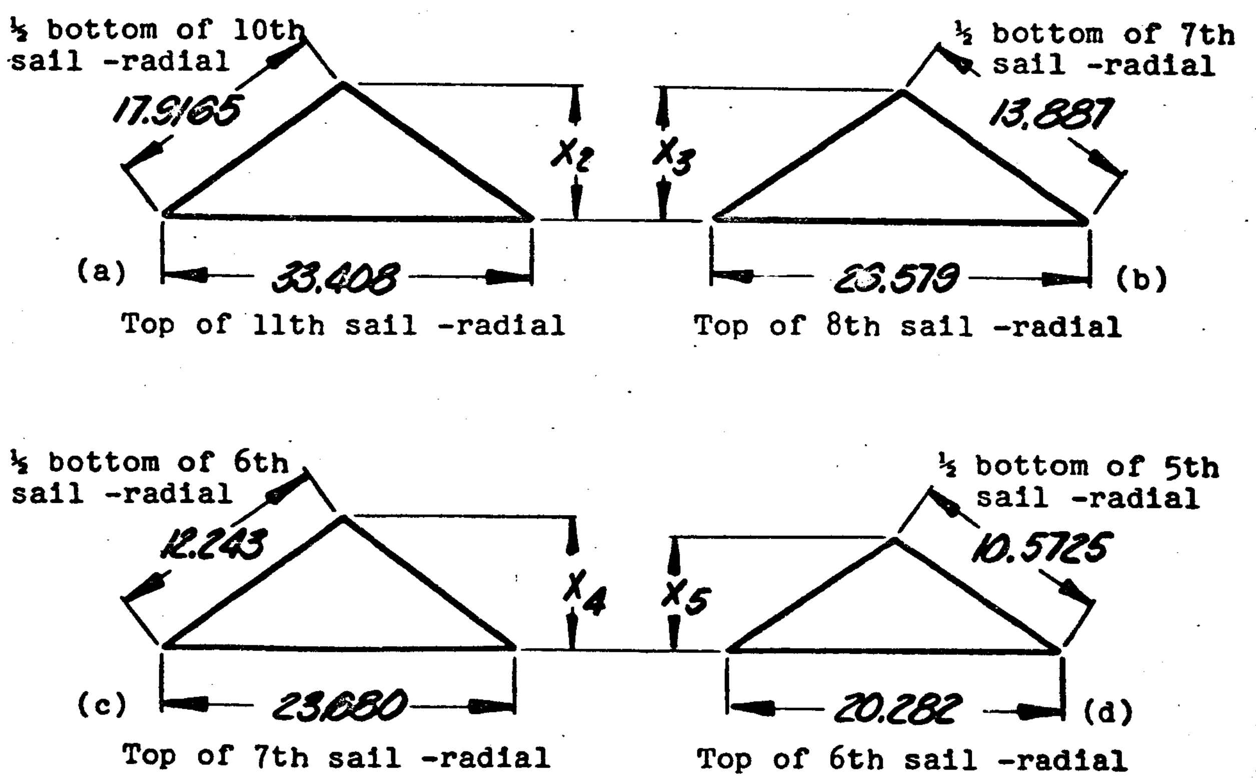


Fig. 4-9. Geometry of the sail scoops.

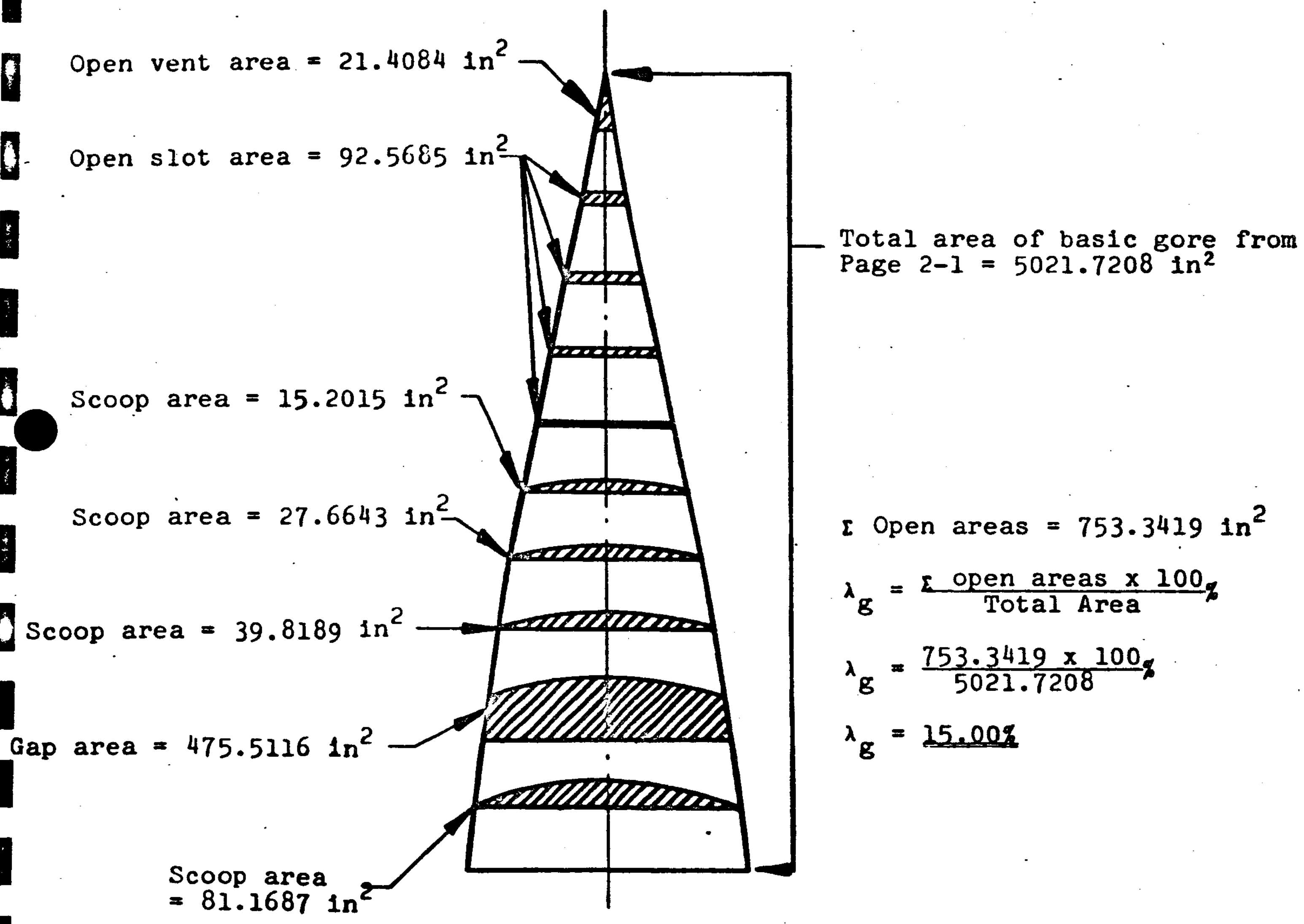


Fig. 4-10. Porosity Distribution

5.0 SNATCH FORCE (SEE FIG. 5-1)

$$V_t = \left(V_m^2 + 2as\right)^{\frac{1}{2}}$$

$$= (120^2 + 2 \times 32.2 \times 32.14)^{\frac{1}{2}}$$

$$= 128.3 \text{ ft/sec.}$$

$$P_s = \left[\frac{(W_c/g)V_t^2 \times (\text{no. of gores}) \times (\text{line strength})}{(\ell_s + \ell_r) \times (\%\ \text{elongation})}\right]^{\frac{1}{2}}$$

$$= \left[\frac{(35/32.2) \times 128.3^2 \times 36 \times 550}{50 \times 0.30}\right]^{\frac{1}{2}}$$

$$= 4860 \text{ lb.}$$

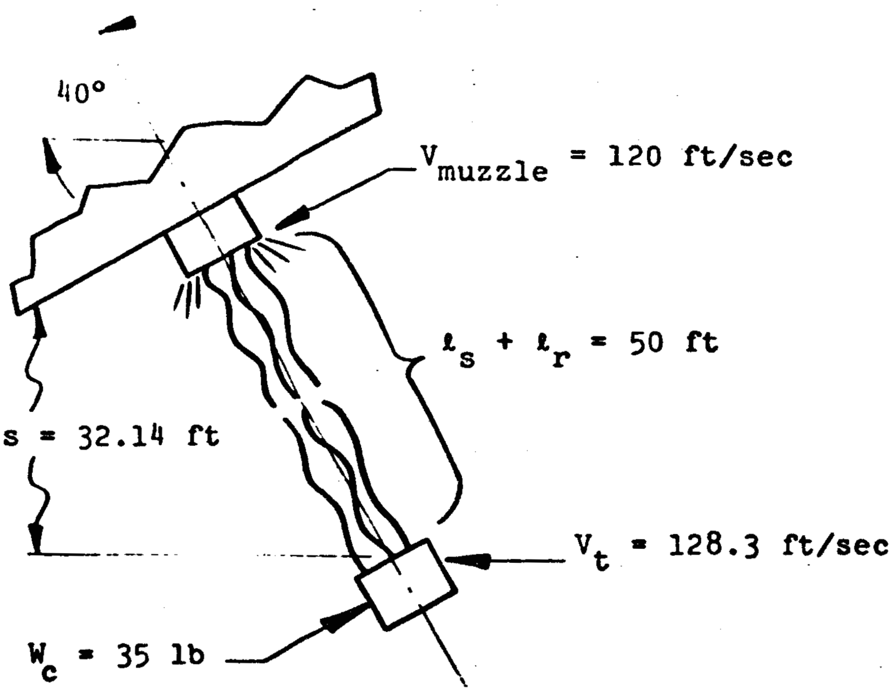


Figure 5-1. Design considerations for calculating snatch force at line stretch, due to mortar firing downward.

6.0 OPENING FORCE

The opening force of the 40-ft ringsail was obtained from a computed trajectory. The actual computer run is included in Appendix A.

The starting conditions assumed a C_D of 0.6 and an inflation time of 0.35 sec (see Fig. 6-1).

The deployment conditions as defined by the procurement specification and hence used as starting conditions for this trajectory were

$$q = 12.0 \text{ lb/ft}^2,$$

$$V = 1650 \text{ ft/sec, and } H = 128{,}300 \text{ ft},$$

$$M = 1.6.$$

From the above assumptions and conditions, the computed opening force was 7958 lb.

7.0 PARACHUTE SIZING

The size of the parachutes to be manufactured was defined by the Martin Company Procurement Specification. Since there was no indication that the specified size would present any problems as far as strength, weight, or volume were concerned, no change in size was proposed.

8.0 STRESS ANALYSIS

The margins of safety calculated for this parachute are summarized in Fig. 8-1, and the design factors used are given in Table 8-1.

Ultimate suspension-line load.

$$P_{ult.} = (\text{no. of lines}) \times (\text{line strength})$$

$$= 36 \times 550$$

$$= 19{,}800 \text{ lb.}$$

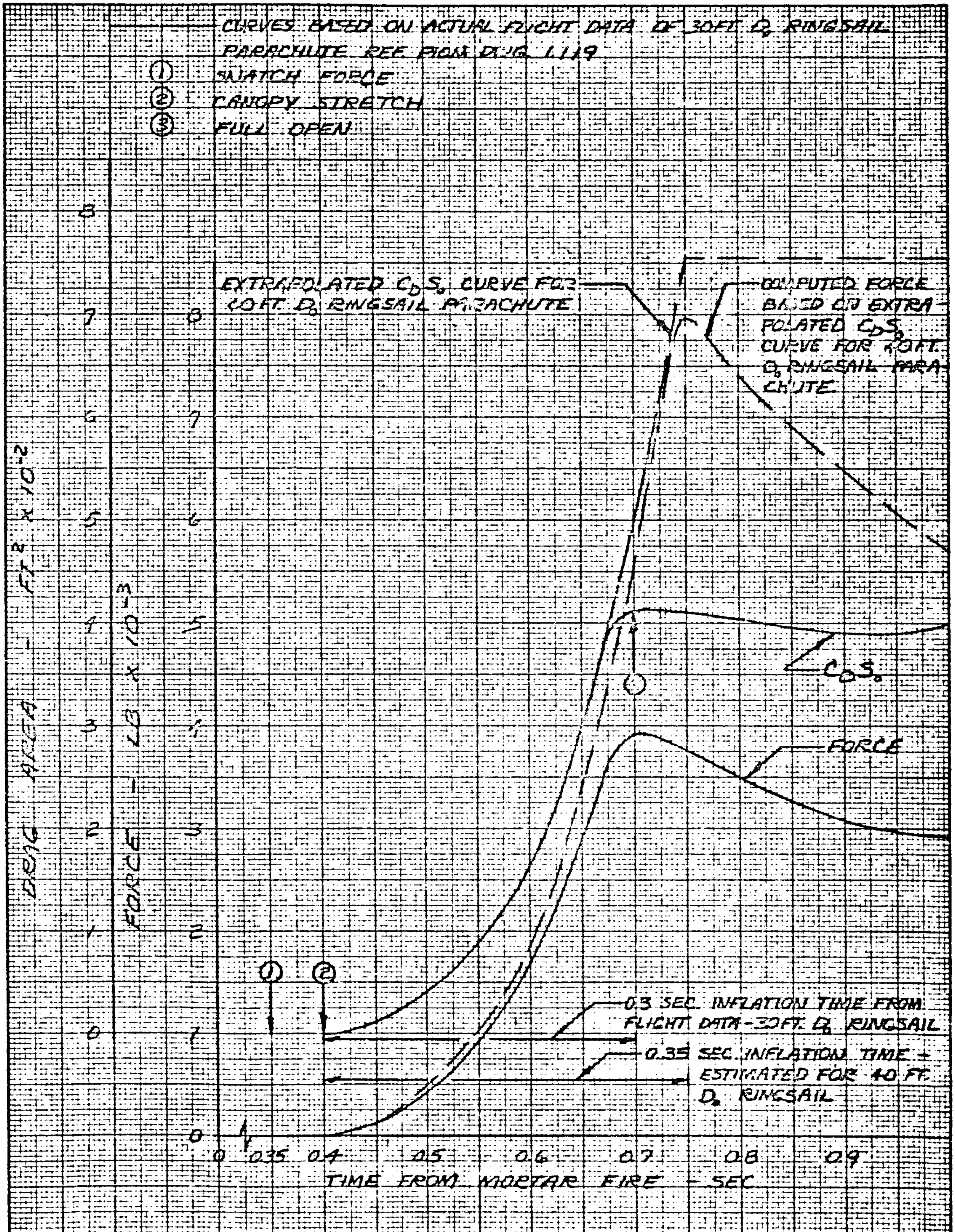
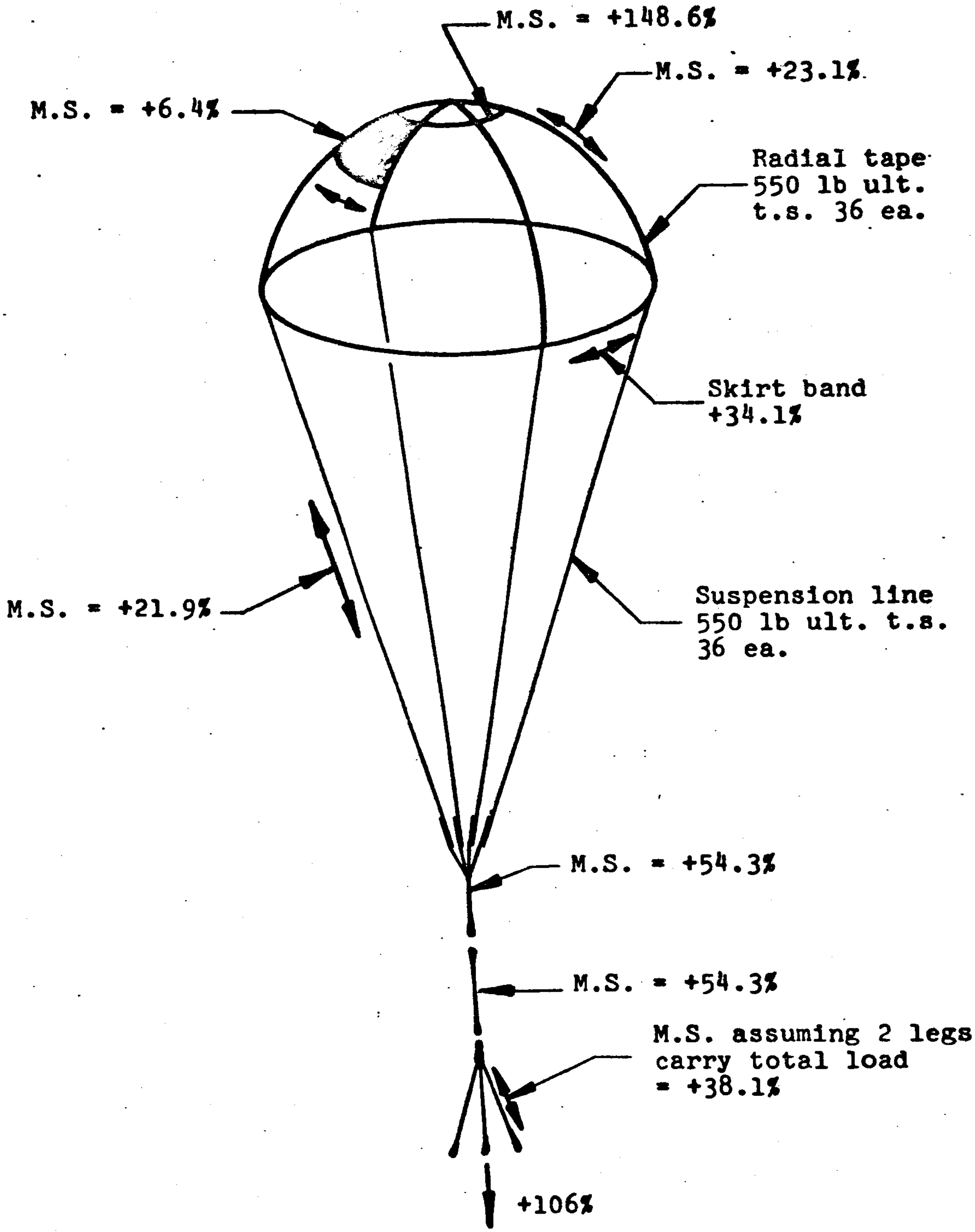


FIGURE 6-1 DRAG AREA VS TIME FOR 40FT. RINGSAIL PARACHUTE



(See Pioneer drawing 1.419.)

Fig. 8-1. Design of the 40-ft-dia. 36-gore ringsail parachute.

TABLE 8-1
STRENGTH LOSS AND SAFETY FACTORS

Symbol	Function	Canopy	Radial tapes	Susp. lines	Vent and skirt band	Canopy riser and interm. riser	Vehicle attach. riser (Bridle)
m	Joint efficiency	0.55	0.90	0.93	0.93	0.80	0.90
n	Heat loss	0.90	0.90	0.90	0.90	0.90	N/A
ℓ	Abrasion	0.96	0.96	0.96	0.96	0.96	0.96
j	Safety factor	1.50	1.50	1.50	1.50	1.50	1.50
c	Line convergence	N/A	N/A	1.04	N/A	N/A	N/A
f	Asymmetrical loading	1.05	1.05	1.05	1.05	1.05	1.05
Design factor $\frac{jcf}{mn\ell}$		3.31	2.02	2.04	1.96	2.28	1.82

Allowable load for suspension lines.

$$P_{allow.} = \frac{P_{ult}}{\text{design factor}}$$

$$= \frac{19,800}{2.04}$$

$$= 9706 \text{ lb.}$$

Margin of safety for suspension lines.

$$M.S. = \frac{\text{load allowable}}{\text{worst-case load developed}} - 1.0$$

$$= \frac{9706}{7958} - 1.0$$

$$= 0.219 \text{ or } + 21.9\%.$$

Ultimate radial-member load. Assume that all radial loads are carried by 36 radial tapes in tension (i.e., the canopy cloth does not carry any radial load).

$$P_{ult} = (\text{no. of radial tapes in tension})$$

$$\times (\text{ult. t.s./tape})$$

$$= 36 \times 550$$

$$= 19,800 \text{ lb.}$$

Allowable load for radial members. The design factor of 2.02 is taken from Table 8-1.

$$P_{allow} = \frac{P_{ult}}{\text{design factor}}$$

$$= \frac{19,800}{2.02}$$

$$= 9,802 \text{ lb.}$$

Margin of safety for radial members.

$$M.S. = \frac{\text{load allowable}}{\text{worst-case load developed}} - 1.0$$

$$= \frac{P_{allow}}{F_o} - 1.0$$

$$= \frac{9802}{7958} - 1.0$$

$$= 0.231 \text{ or } 23.1\%.$$

Load Acting on Main Seam (explanation of Table 8-2).

1. For selected rings, determine (2) cloth area including fullness, less seam allowance and take-up.

2. From spherical coordinates of basic gore dimensions, we obtain total area of crown for combination of ring selected.

3. Assuming that crown inflates with a hemispherical profile (a good assumption since evaluation of ring-sail parachute profiles indicate the profile is very close to a hemisphere), we calculate a radius.

4. From Fig. 8-2, for a given radius, we determine the corresponding force. (A good method since comparison of ring-sail profile to force indicates our assumption of loads vs profile for this configuration is good.)

5. By dividing the force by the cloth area that the force acts on, we can determine the pressure acting on the selected rings.

6. By taking the product of the pressure and radius, we obtain a load in lb/in. at a given point on the main seam. Worst case is for Case 4, where load is 9.68 lb/in. = P_{dev}. Assume maximum load is carried by cloth above gap.

Allowable load for canopy cloth.

$$P_{allow} = \frac{\text{ult strength cloth (warp)}}{\text{design factor}}$$

$$= \frac{34 \text{ lb/in.}}{3.31}$$

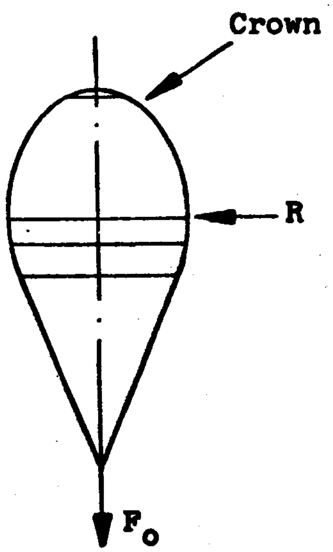
$$= 10.3 \text{ lb/in.}$$

Margin of safety for cloth.

$$\text{M.S.} = \frac{P_{allow}}{P_{dev}} - 1.0 = \frac{10.3 \text{ lb/in.}}{9.68 \text{ lb/in.}} - 1.0$$

$$= 1.064 - 1.0$$

$$= +\ 6.4\%.$$



Apportion F_o to canopy shape, during inflation process, to determine worst case for load on main seam.

TABLE 8-2
CANOPY LOADING

1	2	3	4	5	6	7
Case no.	Cloth area including fullness, less seam allow. and take-up, in^2	Area of crown, in^2	Radius in.	F_o lb	⑤ ÷ ② lb/in^2	⑥ × ④ lb/in.
1	10,378	12,289	44.225	650	0.06263	2.77
2	33,231	35,982	75.67	1875	0.05642	4.27
3	66,947	69,703	105.33	4425	0.0661	6.96
4	110,243	112,983	134.10	7958	0.0722	9.68
5	164,430	180,770	160.00 (= D_p)	7225	0.0439	7.03

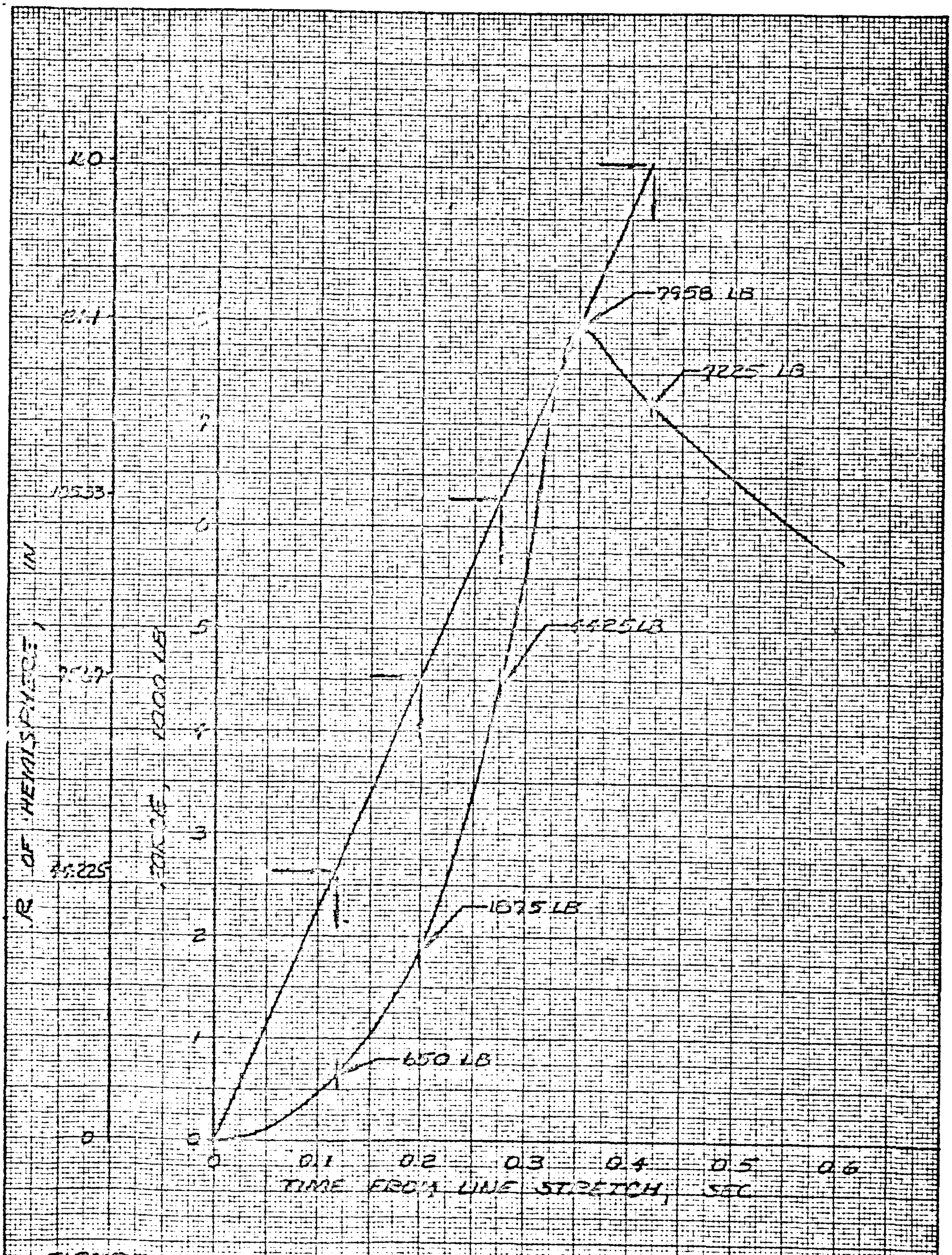
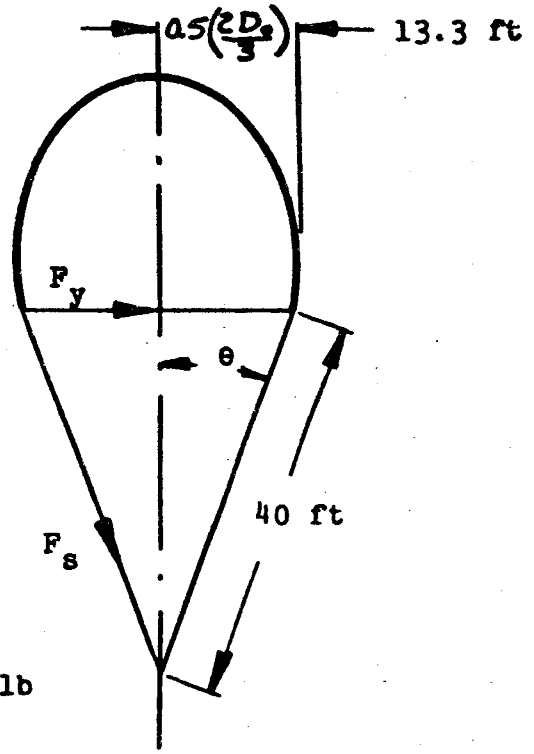


FIGURE 6-7. INFLATED PARACHUTE RADIUS AND FORCE VS TIME

Load developed in skirt band (Method 10)



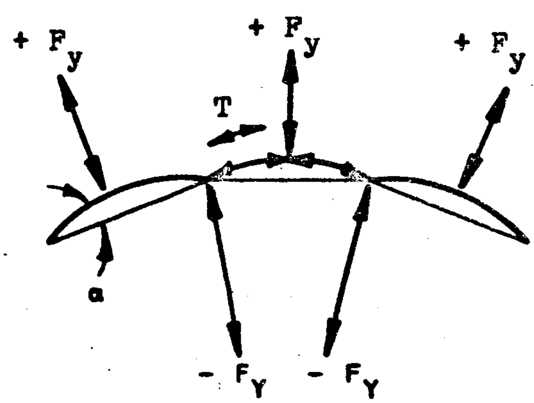
$$F_s = \frac{F_o \text{ max}}{\#\text{lines}}$$
$$= \frac{7958 \text{ lb}}{36}$$
$$= 221.05 \text{ lb}$$

Determine $\measuredangle\theta$

$$\operatorname{cosec} \theta = \frac{40}{13.3}$$
$$= 3.007$$
$$= 19°25'$$
$$\text{Use} = 19\tfrac{1}{2}°$$

Calculate F_y

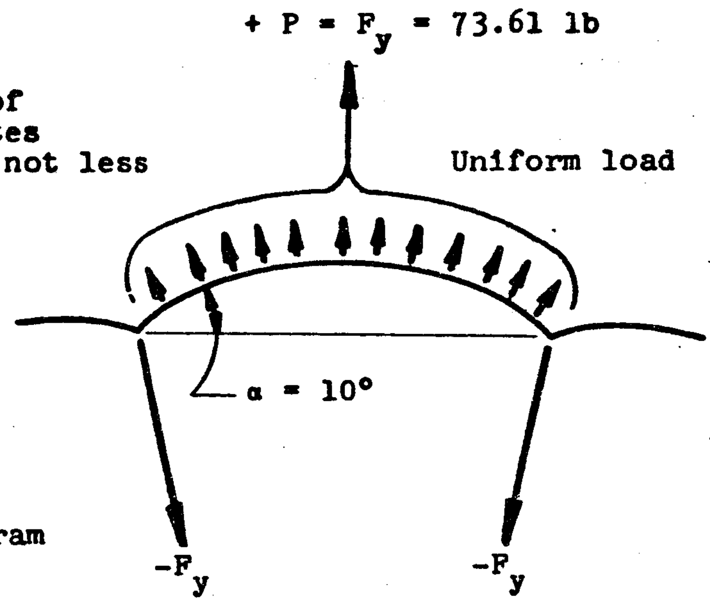
$$F_y = F_s \sin 19\tfrac{1}{2}°$$
$$= 221.05 \times 0.333$$
$$= 73.61 \text{ lb}$$



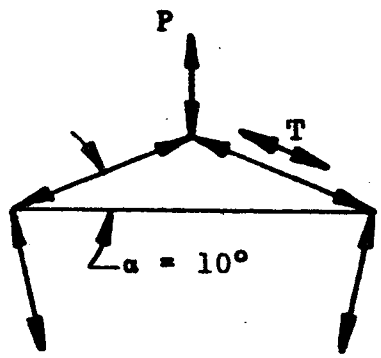
For convenience, we assign F_y forces acting towards the C/L of the parachute-values and + values to the forces acting outwards on the cloth panels.

The tension force (T) in the skirt band is a function of the force + F_y and the $\measuredangle\alpha$ taken by the scallop at the skirt.

NOTE: From evaluation of inflated parachutes $\angle\alpha$ appears to be not less than 10°.



Free Body Diagram



$$P_{dev} = T = \text{ctn}\ \alpha\ \frac{P}{2}$$
$$= 5.671 \times \frac{73.61}{2}$$
$$= 208.72 \text{ lb}$$

<u>Allowable load in skirt band</u>

$$P_{allow} = \frac{\text{ult. t.s. tape (rated)}}{\text{Design Factor}}$$
$$= \frac{550 \text{ lb}}{1.96}$$
$$= 280 \text{ lb}$$

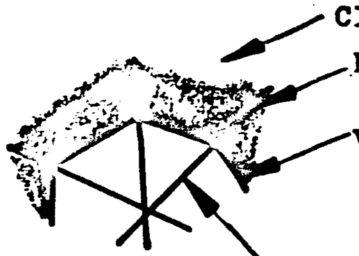
Use Pioneer tape Spec. 66-5, Type II

<u>Margin of safety for skirt band</u>

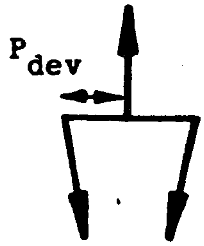
$$\text{M.S.} = \frac{P_{allowable}}{P_{developed}} - 1.0$$
$$= \frac{280}{208.7} - 1.0 = 1.341 - 1.0 = \underline{+34.1\%}$$

Load developed in vent band (Method 13)

From 10 F_y = 73.61 lb. By using a vent tape 7% shorter than constructed diameter of the vent, we are able to carry at least 20% of the F_y load in the vent tape.



Free-body Diagram

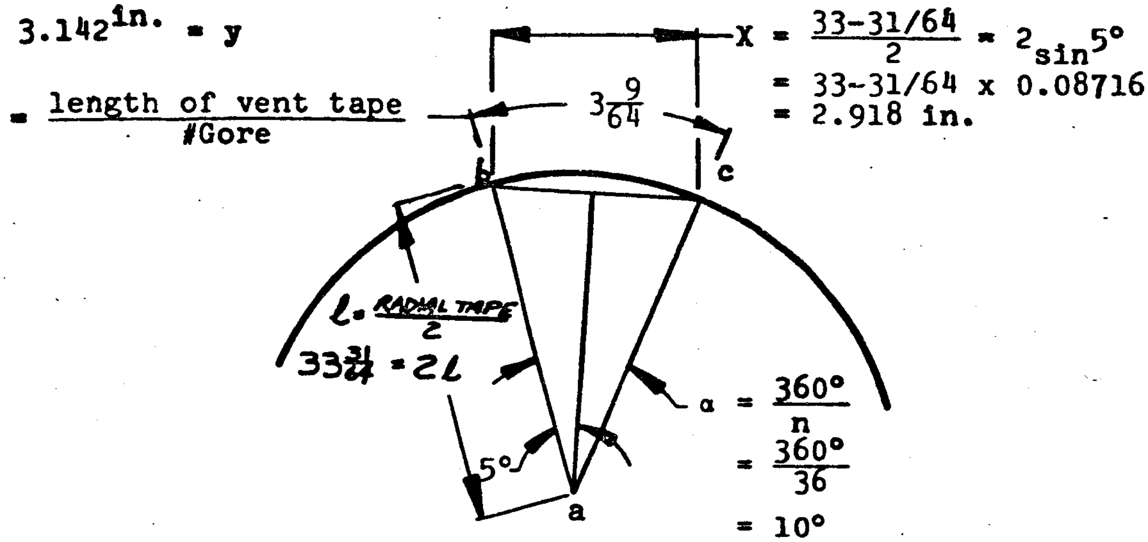


$$F_{vent} = F_y \times .80$$
$$= 58.88 \text{ lb}$$

Use the following formula
We solve for P_{dev}:

$$P_{dev} = \frac{F_{vent}}{2\sin\frac{360°}{2(\#Gores)}}$$
$$= \frac{58.88 \text{ lb}}{2\sin\frac{360°}{2\times 36}}$$
$$= \frac{58.88}{2\sin 5°}$$
$$= \frac{58.88}{.1743} = 337.8 \text{ lb}$$

Alternative method of calculating load developed in vent band



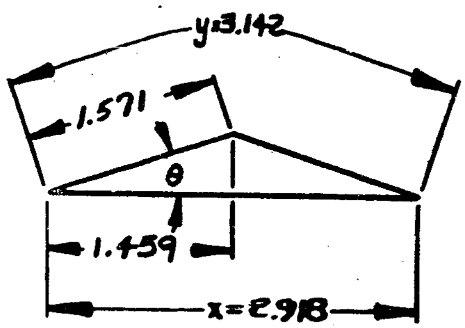
1. Determine $\sharp\alpha$ and $\frac{\alpha}{2}$
2. Determine dimension ℓ
3. Determine dimension x
4. Determine arc y
5. Assume segment bc is an isosceles triangle
6. Determine $\sharp\theta$

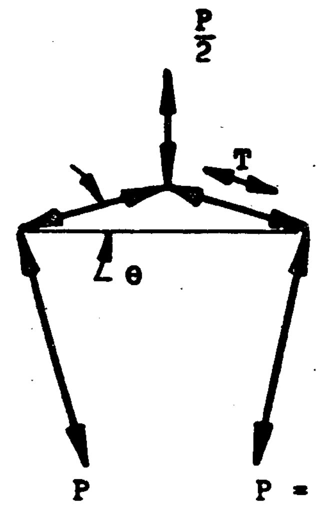
$\cos\theta = \frac{1.459}{1.5711}$

$= 0.92871$

$= 21°46'$

<u>Use 20°</u>





$$P = \frac{F_o max}{\#Gores} = \frac{7958\ lb}{36} = 221\ lb$$

$$P_{dev} = T = CTN\theta \frac{P}{2}$$
$$= 2.747 \times 110.5\ lb$$
$$= 303\ lb$$

NOTE: Since P_{dev} using this method of calculating is less than the load calculated using method (13) we will use the higher loads for determination of margin of safety.

<u>Load allowable for vent band</u>

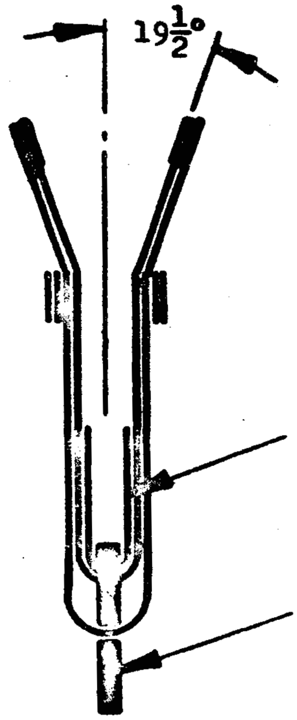
$$P_{allow} = \frac{\text{ult. t.s. tape}}{\text{Design Factor}}$$
$$= \frac{3 \times 550\ lb}{1.96} = 840\ lb$$

(Use 3 ply x 550 lb Pioneer Spec. 66-5, Type II.)

<u>Margin of safety for vent band</u>

$$M.S. = \frac{P_{allowable}}{P_{developed}} - 1.0 = \frac{840\ lb}{337.8\ lb} - 1.0 = 2.486 - 1.0$$
$$= +148.6\%.$$

Riser-part of canopy dwg. 1.419



Load allowable

$$P_{allowable} = \frac{4 \text{ ply} \times 7000 \text{ lb}}{\text{Design Factor}}$$ (Rated strength for MIL-W-25361, Type III)

$$= \frac{28{,}000}{2.28} = 12{,}281 \text{ lb}$$

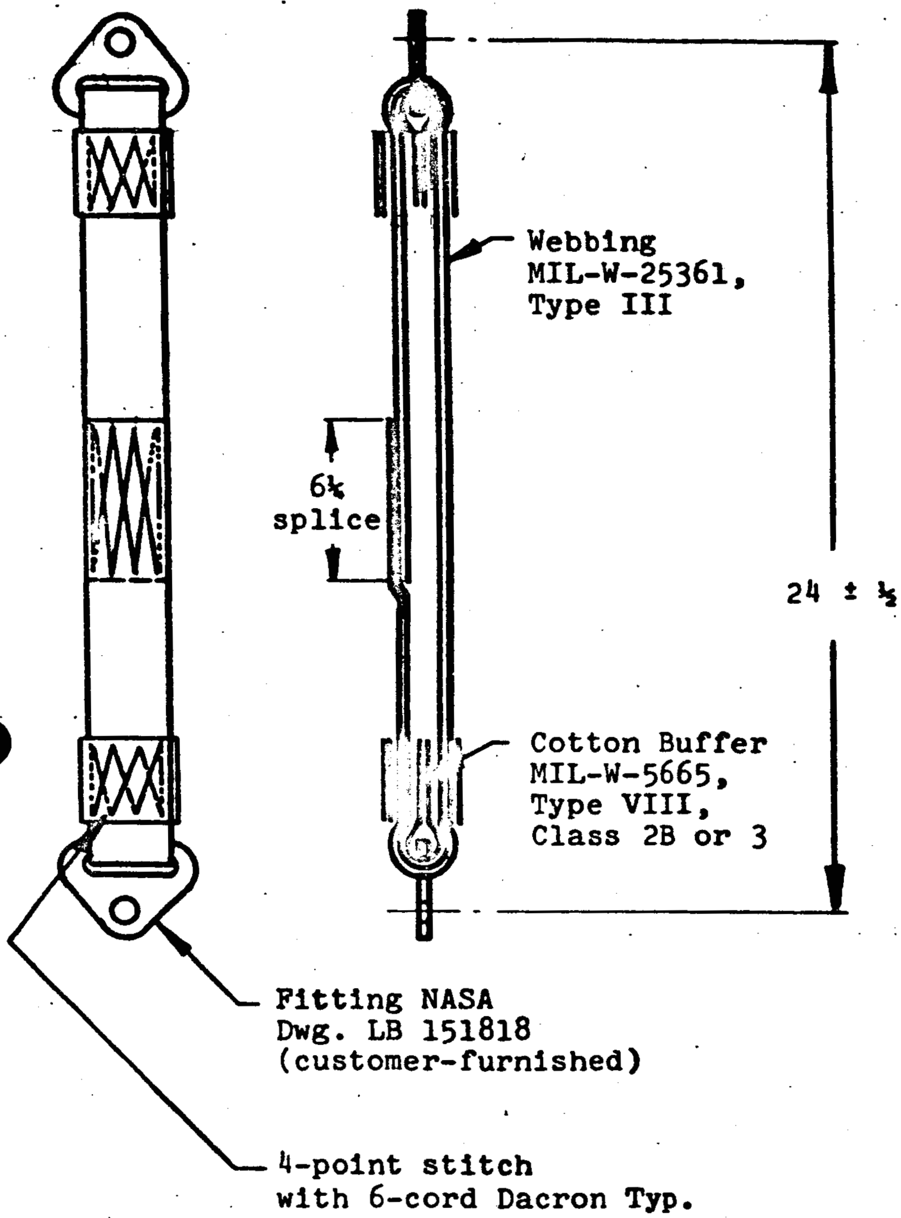
Margin of safety

$$M.S. = \frac{P_{allow}}{P_{dev}} - 1.0 = \frac{12{,}281 \text{ lb}}{7958 \text{ lb}} - 1.0 \qquad P_{dev} = F_o \text{ max}$$

$$= 1.543 - 1.0 = \underline{+54.3\%}$$

Ref: Pioneer Dwg. 3.7333
Intermediate Riser.

*Rated Strength



$P_{allowable}$

$$P_{all} = \frac{4\text{ply} \times 7000^{*}\ \text{lb/ply}}{\text{Design Factor}}$$

$$= \frac{28{,}000\ \text{lb}}{2.28}$$

$$= 12{,}281\ \text{lb}$$

Margin of safety

$$M.S. = \frac{P_{all}}{F_{o\ max}} - 1.0$$

$$= \frac{12{,}281\ \text{lb}}{7{,}958\ \text{lb}} - 1.0$$

$$= 1.543 - 1.0$$

$$= \underline{+54.3\%}$$

Determine number of inches of 4-point stitching required for splice (100% theo. efficiency).

Web ult t.s. 7000 lb rated, 8500 lb actual
Rated strength of 6-cord Dacron 41.0 lb
Efficiency of stitching 0.75
5 stitches/in.

1. Determine no. stitches req.

$$\text{Number of stitches req.} = \frac{\text{web act. ult. t.s.}}{2\ (\text{rated strength cord} \times \text{efficiency})}$$

$$= \frac{8500}{2 \times 41.0 \times 0.75} = 138 \text{ stitches}$$

2. Determine no. of inches of stitching req.

$$\text{No. of inches of stitching} = \frac{\text{No. stitches}}{\text{stitches/in.}} = \frac{138}{5} = 27.6 \text{ in.}$$

3. Determine no. of inches of 4-point stitches
4 point makes 8 rows of stitches.

$$\text{No. inch 4 point} = \frac{\text{No. of inch of stitches}}{\text{8 row/in.}}$$

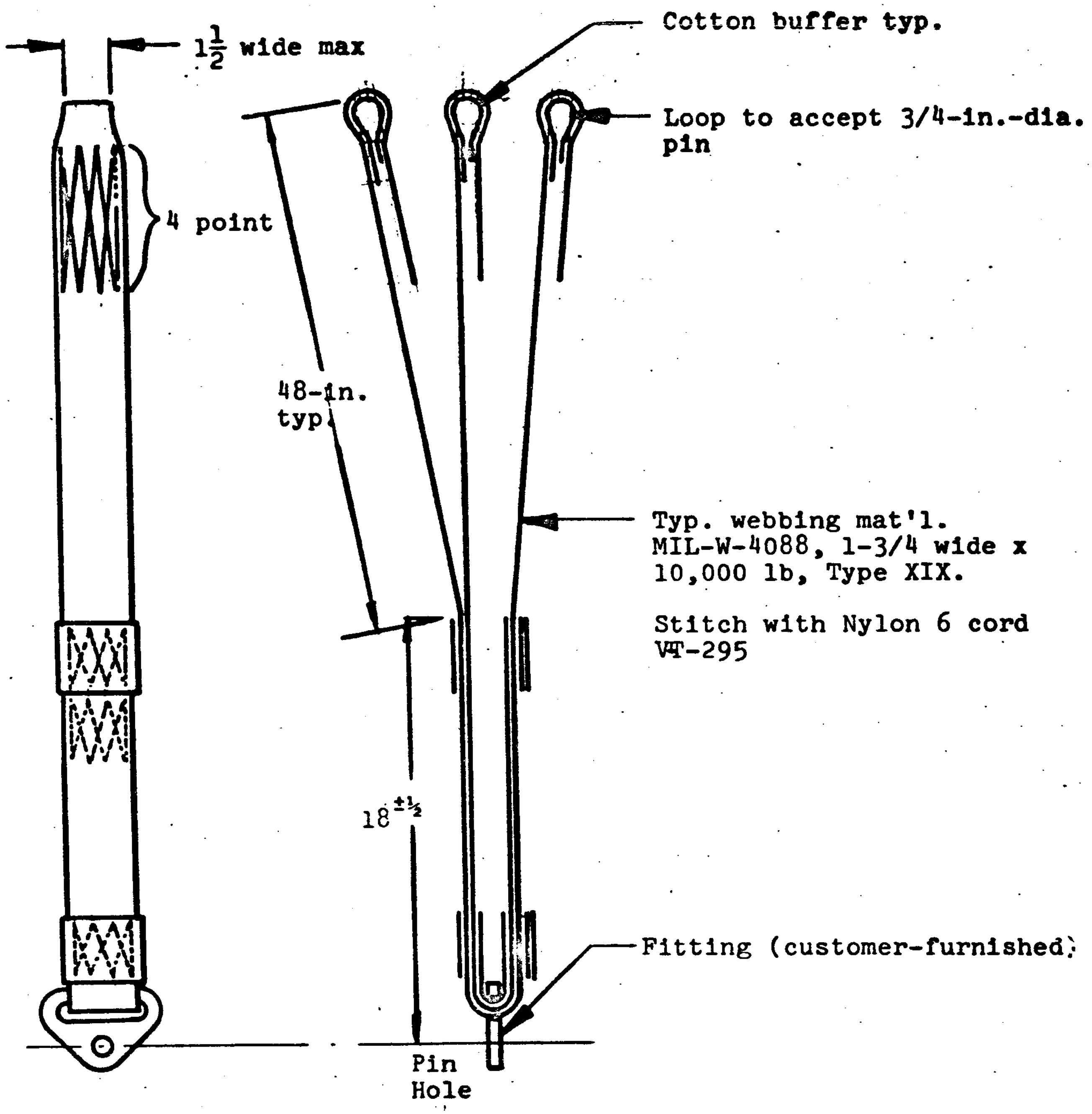
$$= \frac{27.6 \text{ in.}}{\text{8 row/in.}}$$

$$= 3.48 \text{ in. (min. without design factor)}$$

4. Using design factor of $1.74 = \frac{\text{Safety factor}}{\text{Heat loss} \times \text{abrasion}}$

Calculate length of 4 point for splice. $= \frac{1.5}{0.90 \times 0.96}$

Length of 4 point = Min length x design factor
= 3.48 x 1.74
= 6.00 in.



<u>P_{allow} on two legs</u>

$$P_{all} = \frac{2ply \times 10{,}000 \text{ lb/ply}}{\text{Design Factor}} = \frac{20{,}000}{1.82} = 10{,}990 \text{ lb}$$

<u>Margin of safety (two legs)</u>

$$M.S. = \frac{P_{all}}{F_{o\,max}} - 1.0 = \frac{10990}{7958} - 1.0 = 1.381 - 1.0$$

$$= .381 \text{ or } 38.1\%$$

P_{allow} (equal load)

$$P_{all} = \frac{3ply \times 10{,}000\ lb/ply}{Design\ Factor} = \frac{30{,}000}{1.82} = 16450\ lb.$$

Margin of safety (equal load)

$$M.S. = \frac{P_{all}}{F_{o\ max}} - 1.0 = \frac{16450}{7958} - 1.0 = 2.06 - 1.0$$

$$= 106\%$$

Determine number of inches of 4-point stitching req. at loop ends.

$$\text{No. of stitches req.} = \frac{\text{Web rated strength}}{2(\text{rate strength of cord} \times \text{efficiency})}$$

$$= \frac{10{,}000\ lb}{2(50\ lb \times 0.75)} = \frac{10{,}000}{75}$$

$$= 133\ \text{stitches}$$

Determine no. of inches of stitching req.

$$\text{No. of inches of stitching} = \frac{\text{No. of stitches}}{\text{stitches/in.}}$$

$$= \frac{133}{5} = 26.6\ \text{in.}$$

Determine no. of inches of 4 point (4 point makes 8 rows of stitching).

$$\text{No. inches 4 point} = \frac{26.6\ \text{in.}}{8\ \text{row/in.}} = 3.32\ \text{in.}$$ (min. without safety factor) (use 1.50)

$$= 3.32 \times 1.5$$

$$= 5.0\ \text{inches}$$

9.0 WEIGHT BREAKDOWN

The weight of the complete parachute system supplied by Pioneer Parachute was 38.8 lb and is summarized in Table 9-1. This meets the 40-lb maximum weight requirement.

9.1 Parachute (Pioneer Dwg. 1.419)

The total weight of the parachute itself is 31.66 lb, consisting of Dacron cloth, tapes, cord, and thread.

9.1.1 Cloth

The parachute utilizes 1.9-oz/yd^2 Dacron cloth in Ring 1 and 1.0-oz/yd^2 Dacron cloth in the remainder of the canopy.

The quantity of 1.9-oz cloth required per canopy is 4.5 yd^2. This represents a weight of 0.535 lb.

The quantity of 1.0-oz cloth required per canopy is 145 yd^2. This represents a weight of 9.062 lb.

9.1.2 Radial Tapes

The radial tapes are 3/4-in.-wide, 550-lb Dacron tape, weighing 0.26 oz/yd. The quantity required per canopy is 270 yd. This represents a weight of 4.388 lb.

9.1.3 Radial-gap-reinforcing Tapes

The gap-reinforcing tapes are 3/4-in.-wide 300-lb Dacron tape weighing 0.16 oz/yd. The quantity required per canopy is 24 yd. This represents a weight of 0.240 lb.

9.1.4 Skirt Reinforcing

The canopy skirt is reinforced with a single 3/4-in.-wide 550-lb Dacron tape weighing 0.26 oz/yd. The quantity required per canopy is 41 yd. This represents a weight of 0.666 lb.

TABLE 9-1
WEIGHT BREAKDOWN

Item	Qty. yds.	Unit wt	Total wt (lb)
1.0 Parachute			
1.1 1.9-oz Dacron cloth - Ring 1	4.5	1.90 oz/yd^2	0.535
1.2 1.0-oz Dacron cloth - Rings 2, 3, & 4 Sails 5-8, 10, 11	145	1.00 oz/yd^2	9.062
1.3 Radial tapes - 3/4" x 550 lb	270	0.26 oz/yd	4.388
1.4 Radial gap reinf. - 3/4" x 300 lb	24	0.16 oz/yd	0.240
1.5 Skirt tape - 3/4" x 550 lb	41	0.26 oz/yd	0.666
1.6 Vent tapes - 3/4" x 550 lb x 3ply	10	"	0.163
1.7 Ring reinf. tapes - 3/4" x 550 lb	86	"	1.398
1.8 Sail reinf. tapes - 3/4" x 300 lb	312	0.16 oz/yd	3.120
1.9 Suspension lines - 550-lb cord	492	61 yd/lb	8.066
1.10 Thread - allow approx.	-	-	1.000
1.11 Reefing ring	36ea	0.26 oz	0.585
1.12 Reefing ring tapes - 3/4" x 550 lb	4.63	0.26 oz/yd	0.081
1.13 Post reefing lines - 550-lb cord	95	61	1.557
1.14 Blue stripe	7.5	1.6 oz/yd^2	0.750
1.15 Radial loop buffer	6	0.14 oz/yd	0.053
SUB TOTAL (Parachute)			31.664
2.0 Attached riser	-	-	1.500
3.0 Intermediate riser	-	-	1.313
4.0 Secondary riser	-	-	0.281
5.0 Vehicle attachment riser	-	-	1.594
6.0 Deployment bag	-	-	
6.1 Deployment bag	-	-	1.281
6.2 Balsa block	-	-	1.250
TOTAL WEIGHT OF SUPPLIED PARTS			38.883

9.1.5 Vent Reinforcing

The vent of the parachute is reinforced with three 3/4-in.-wide 550-lb Dacron tapes. The quantity required per canopy is 10 yd. This represents a weight of 0.163 lb.

9.1.6 Suspension Lines

The suspension lines for this canopy are of 550-lb Dacron cord weighing 61 yd/lb. The required amount per parachute is 492 yd. This represents a weight of 8.066 lb.

9.1.7 Ring and Sail Reinforcings

The leading and trailing edges of all rings and sails, except where skirt and vent hems are formed, are reinforced with 3/4-in.-wide Dacron tape. The 550-lb tape is used for the rings and the 300-lb tape for the sails. The quantity of 550-lb tape required per canopy is 86 yd, which represents a weight of 1.398 lb. The amount of 300-lb tape required is 312 yd, which represents a weight of 3.120 lb.

9.1.8 Reefing Rings

Thirty-six reefing rings are required, adding a weight of 0.585 lb.

9.1.9 Reefing-ring Tapes

The reefing-ring tapes are made of 3/4-in. 550-lb Dacron tape folded in half. Five yards is required, weighing 0.081 lb.

9.1.10 Post Reefing Lines

The reefing-line material is the same as the suspension lines. Ninety-five yards is required, for a weight of 1.557 lb.

9.1.11 Blue Stripe

When the 1.0-oz Dacron cloth was inked blue for the identification stripe, the cloth weight was increased to 1.6 oz/yd^2.

The quantity of cloth required is 7.5 yd, yielding a weight of 0.75 lb.

9.1.12 Radial-loop Buffer

The radial-loop buffer is 3/4-in.-wide cotton tape weighing 0.14 oz/yd. The quantity required is 6 yd, which represents 0.053 lb.

9.1.13 Thread

Allowance is made for approximately 1 lb of thread.

9.2 Attached Riser

The riser to which the suspension lines are sewn weighs 1.5 lb. This weight was not divided into individual material weights.

9.3 Intermediate Riser

The intermediate-riser weight also was not itemized. Its total weight is 1.313 lb.

9.4 Secondary Riser

The secondary riser is a length of 2000-lb cord weighing 0.281 lb.

9.5 Vehicle-attachment Riser (Bridle)

The weight of this riser was not separated into component parts. The total weight is 1.594 lb.

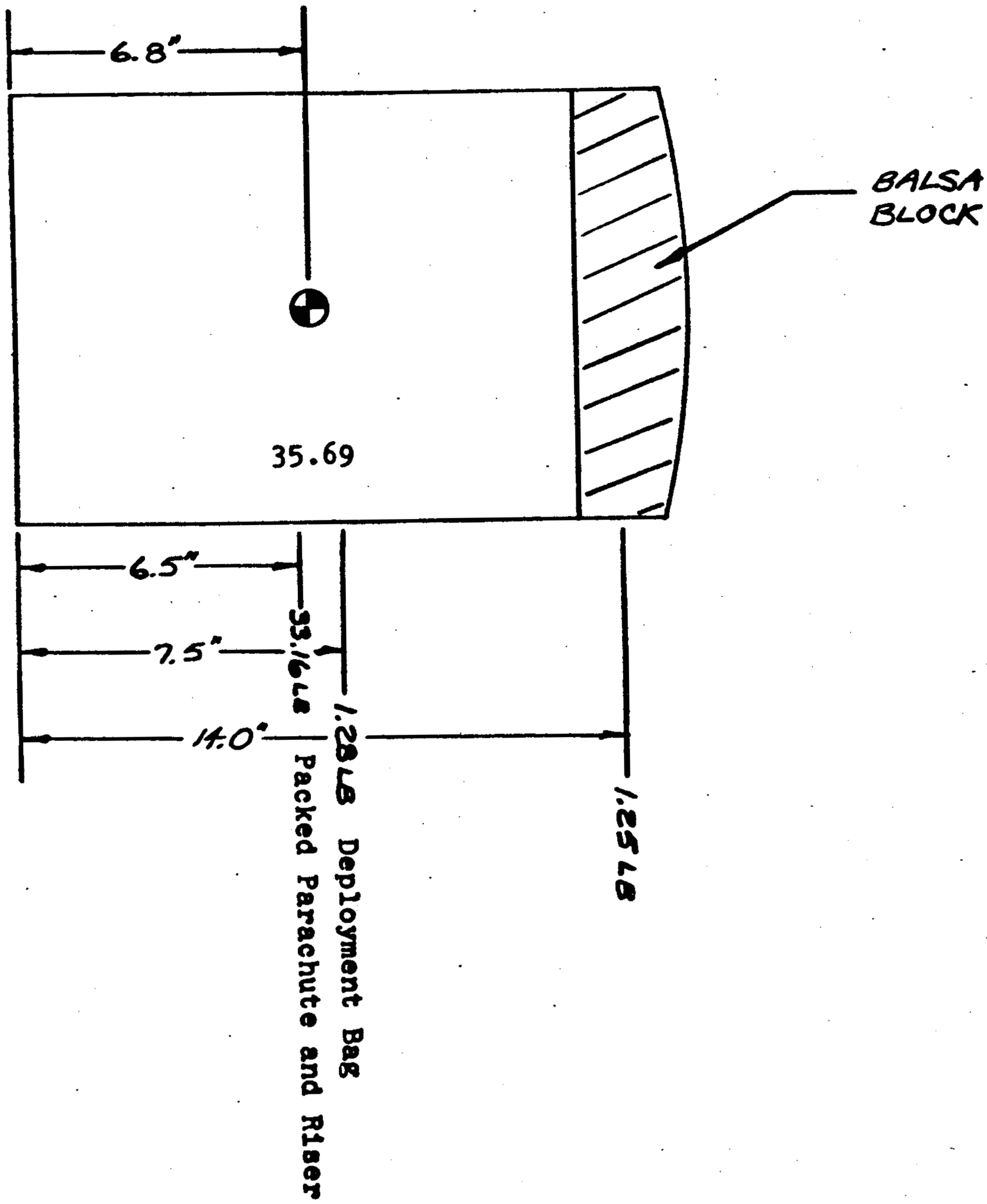
9.6 Deployment Bag

The deployment bag itself weighs 1.281 lb, and the balsa block weighs 1.25 lb, yielding a total weight of 2.531 lb.

10.0 CENTER OF GRAVITY

10.1 Packed Parachute

The following sketch shows the center-of-gravity location for the packed parachute.



Length (ℓ) in.	Weight (w) lb	(ℓ) · (w) = (m) in.-lb
6.5	33.16	215.54
7.5	1.28	9.60
14.0	1.25	17.50

$$\Sigma(w) = 35.69 \text{ lb}$$

$$\Sigma(m) = 242.64 \text{ in lb}$$

$$\frac{\Sigma(m)}{\Sigma(W)} = 6.80 \text{ in}$$

Center-of-gravity is at 6.80 in

10.2 "Strung-out" Parachute

The weight breakdown for the center-of-gravity calculations for the "strung-out" parachute is shown in Fig. 10.1, and the locations for the weights are given in Fig. 10.2, which also shows the center-of-gravity location for the "strung-out" parachute. The calculations are shown in Table 10-1.

10.3 Inflated Parachute

The weight breakdown for the center of gravity calculations for the inflated parachute is shown in Fig. 10-1, and the locations for the weights are given in Fig. 10-3, which also shows the center-of-gravity location for the inflated parachute. The calculations are shown in Table 10-2. The center-of-gravity of the included air mass is as follows.

$$r = 13.591$$

$$c.g = (3/8)r + 608.57 \text{ (from Fig. 10-3)} = 669.66 \text{ in.}$$

The weight of the included air mass is as follows

$$w = \rho \times (2/3)\pi r^3$$

at 128,000 ft altitude $w = 0.047$ lb.

Figure 10-1. Weight breakdown for c.g. calcs.

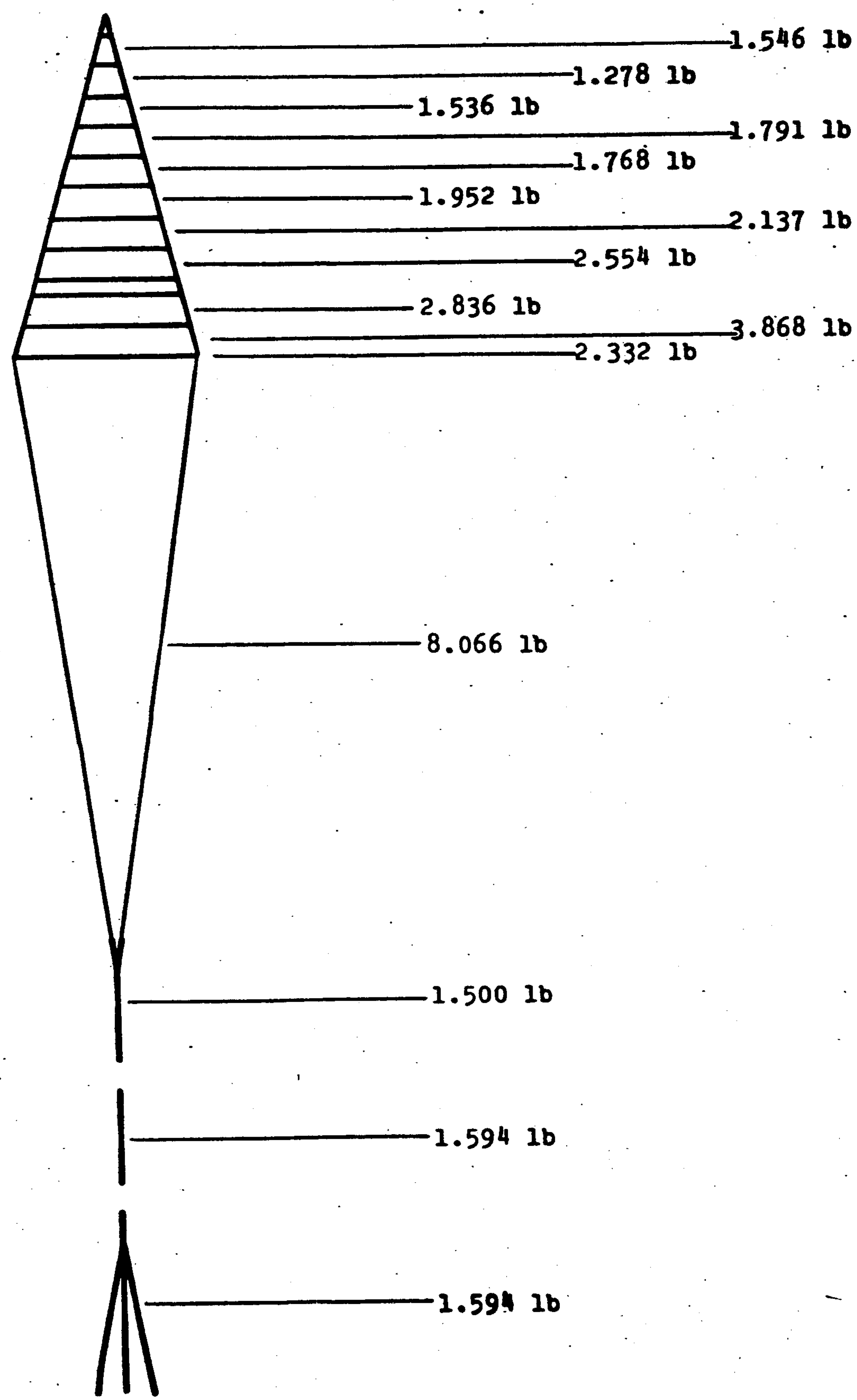
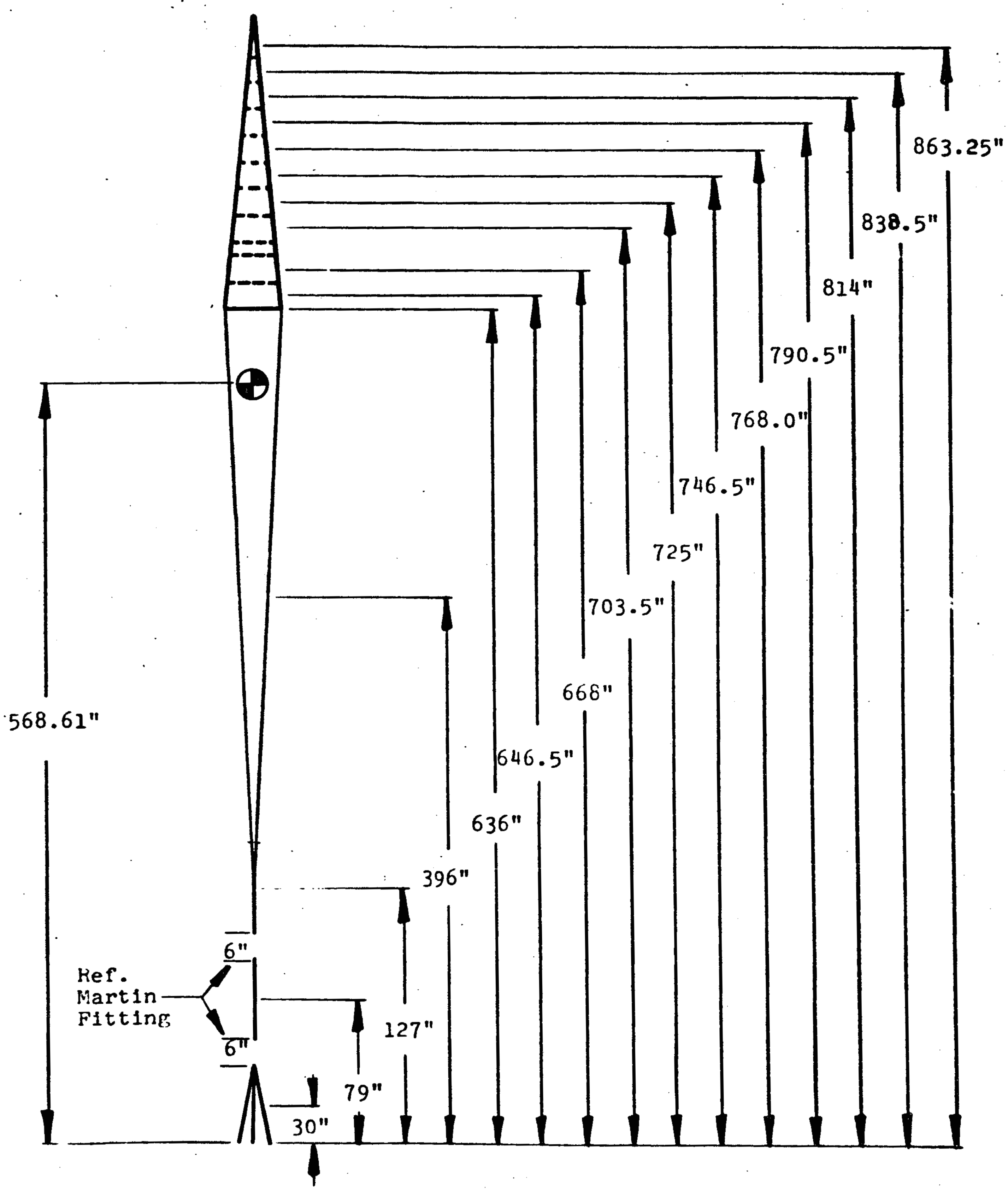


Figure 10-2. Location of weights breakdown for "strung-out" parachute.



<u>Calculation of c.g. for 40-ft Ringsail</u>

Lengths taken from Figure 10-2.

Weights taken from Figure 10-1.

NOTE: Following values are for uninflated "strung-out" canopy.

TABLE 10-1

Length (ℓ) in.	Weight (w) lb	(ℓ) x (w) = (m) in·lb
30.00	1.594	47.82
79.00	1.594	125.93
127.00	1.500	190.50
396.00	8.066	3194.14
636.00	2.332	1483.15
646.50	3.868	2500.66
668.00	2.836	1894.45
703.50	2.554	1796.74
725.00	2.137	1549.33
746.50	1.952	1457.17
768.00	1.768	1357.82
790.50	1.791	1415.79
814.00	1.536	1250.30
838.50	1.278	1071.60
863.25	1.546	1334.58

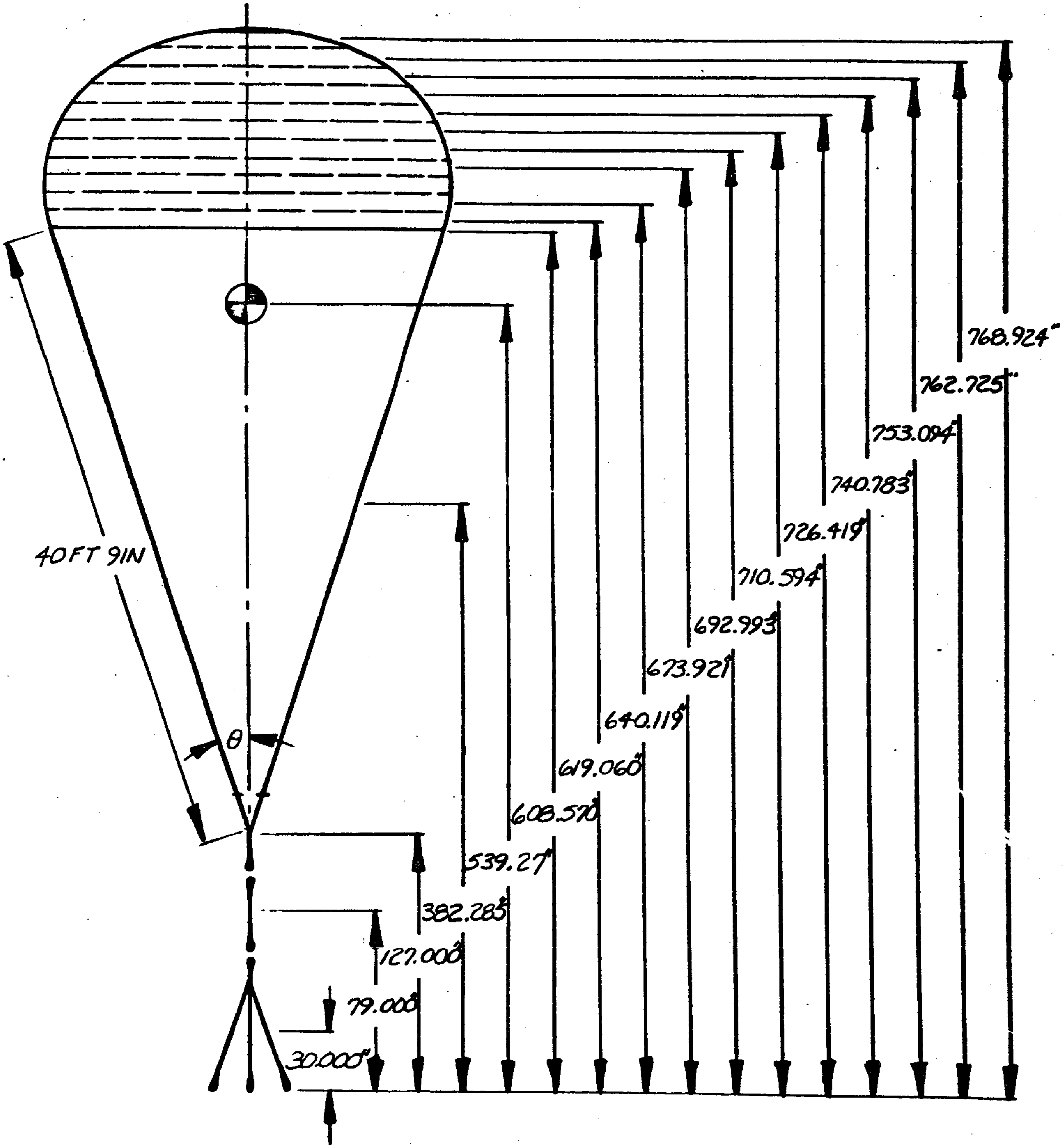
$\Sigma(w) = 36.352$ lb

$\Sigma(m) = 20669.98$ in·lb

$$\frac{\Sigma(m)}{\Sigma(w)} = 568.61 \text{ in.}$$

c.g. is at <u>568.61 in</u>.
(marked on Figure 10-2.)

Figure 10-3 Length Breakdown for c.g. Calculations for Inflated Chute



Weights taken from Figure 10-1.

Lengths taken from Figure 10-3.

Length (ℓ) in.	Weight (w) lb	(ℓ) × (w) = (m) in·lb
30.00	1.594	47.82
79.00	1.594	125.93
127.00	1.500	190.50
382.285	8.066	3083.51
608.570	2.332	1419.19
619.06	3.868	2394.52
640.119	2.836	1845.38
673.921	2.554	1721.19
692.993	2.137	1480.93
710.594	1.952	1387.08
726.419	1.768	1284.31
740.783	1.791	1326.74
753.094	1.536	1156.75
762.725	1.278	974.76
768.924	1.546	1188.76
669.66	0.047	31.474

$\Sigma(w) = 36.399$ lbs

$\Sigma(m) = 19628.84$ in·lb

$$\frac{\Sigma(m)}{\Sigma(w)} = 539.27 \text{ in.}$$

c.g. is at 539.27 in.

(marked on Figures 10-3 and 11-1.)

*included air mass

TABLE 10-2

11.0 PARACHUTE ASSEMBLY MASS MOMENTS OF INERTIA

11.1 Parachute Assembly and Its C.G. Location

Figure 11-1 depicts the characteristics of a ringsail parachute assembly, which upon canopy inflation takes the shape of a hemisphere. Using axis A-A as a base reference the parachute assembly c.g. location can be expressed as

$$\bar{z}_{A-A} = [(W_c + W_b)z_1 + W_a z_2 + W_s z_3 - W_r z_4]/W_T \qquad (11\text{-}1)$$

For the 40-ft D_o ringsail, Table 11-1 lists the evaluated characteristics. Use of the above equation results in

$$\bar{z}_{A-A} = 34.5 \text{ ft} \qquad (11\text{-}2)$$

The location of the system c.g. with respect to the y-y axis is therefore given by

$$\bar{z}_{y-y} = -[39.43 - 34.5] = -4.96 \text{ ft} \qquad (11\text{-}3)$$

11.2 Canopy Material

11.2.1 Roll Inertia of Fabric Circumferential Bands That Make Up Canopy (with respect to z-z axis).

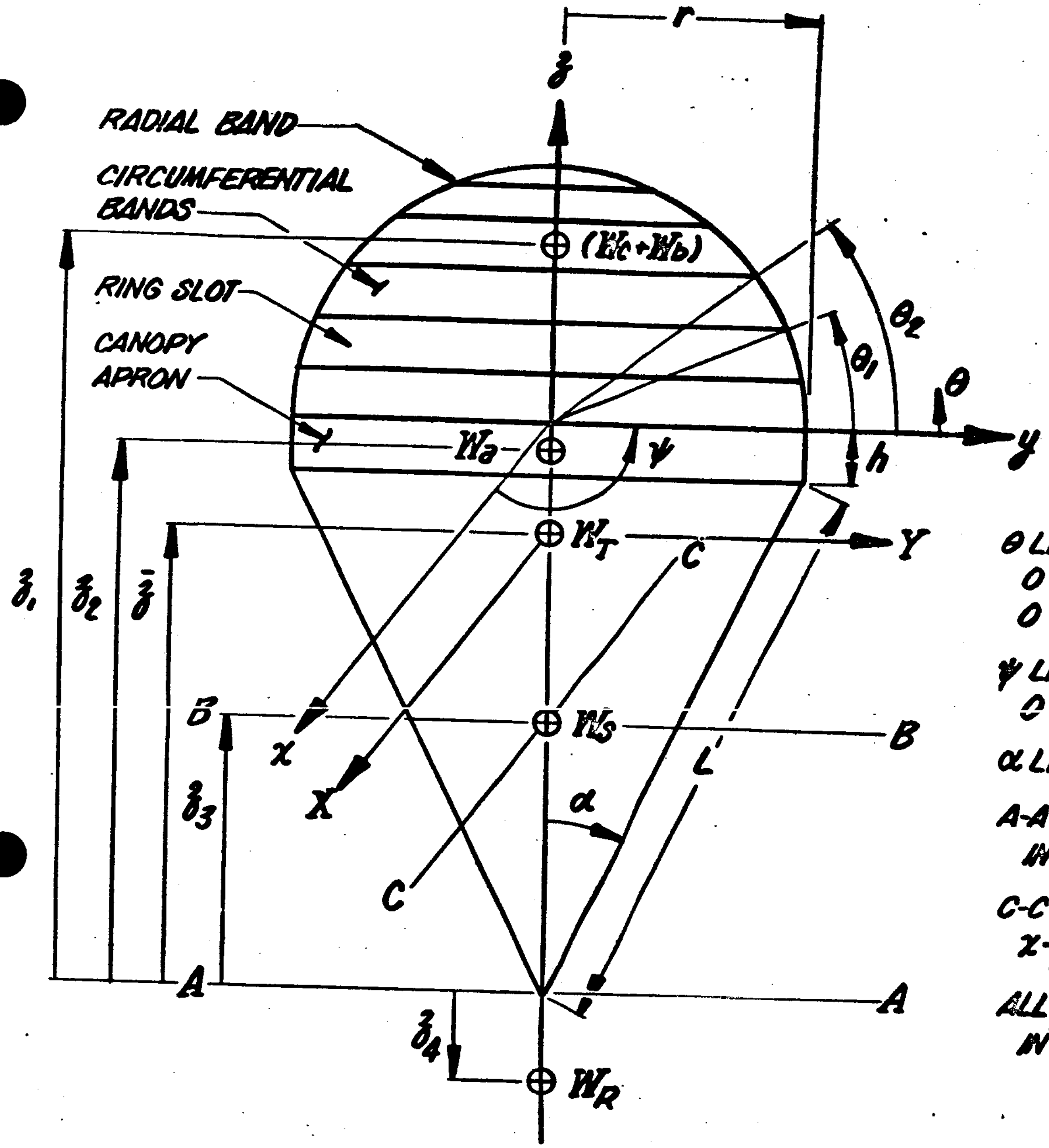
The roll mass moment of inertia can be shown to be

$$I_{z-z} = \sum^{n}[2/3\pi m_c r^4\{\sin\theta_2(\cos^2\theta_2 + 2) - \sin\theta_1(\cos^2\theta_1 + 2)\}] \qquad (11\text{-}4)$$

where m_c is the canopy material mass distribution per unit area and n is the number of circumferential rings.

Table 11-2 depicts the properties associated with the circumferential rings used on the 40-ft D_O ringsail parachute. Evaluation of equation (11-4) yields

$$I_{z-z} = 73.197 \text{ lb-ft-sec}^2 \qquad (11\text{-}5)$$



θ LIES IN THE y-z PLANE
$0 \leq \theta_2 \leq \pi/2$
$0 < \theta_1 \leq \theta_2$

ψ LIES IN THE x-y PLANE
$0 \leq \psi \leq \pi/2$

α LIES IN THE y-z PLANE

A-A AND B-B AXIS LIE IN y-z PLANE

C-C AXIS LIES IN THE x-z PLANE

ALL z DIMENSIONS LIE IN y-z PLANE

FIGURE II-1 PARACHUTE ASSEMBLY

TABLE 11-1

Characteristics of 40-ft D_o Ringsail Parachute Assembly.

ITEM	W (lbs)	z (ft)	Description
W_c	16.60	48.08	Canopy Material
W_b	4.64	48.08	36 Radial Bands
W_a	2.31	39.43	Canopy Apron
W_s	8.05	19.70	36 Shroud Lines
W_r	4.70	-5.30	Riser Assembly
W_T	36.30	$\bar{z}$	Parachute Assembly total weight

h, canopy apron width = 0.062 ft

α, angle made between any shroud line and system centerline = 19.5°

r, canopy inflated radius = 13.591 ft

L, shroud line length = 40.0 ft

TABLE 11-2

Properties of Fabric Circumferential Rings Associated With 40 Ft D_o Ringsail Parachute Canopy.

RING NO.	WT. (LB)	θ_1 (deg)	θ_2 (deg)
1	1.017	76.3	83.4
2	.878	67.4	75.0
3	1.136	58.8	66.4
4	1.391	50.5	58.1
5	1.368	42.7	50.2
6	1.552	35.0	42.7
7	1.737	27.42	35.0
8	1.905	19.88	27.42
9	0	---	---
10	2.187	7.38	14.95
11	3.468	0	7.38

Total 16.637 lb

Total area of 11 circumferential rings (total canopy cloth area) = 1142 ft^2

$$m_c = \frac{16.637}{32.2\ (1142)} = .452 \times 10^{-3}\ \text{lb-sec}^2/\text{ft}^3$$

11.2.2 Pitch and Yaw Inertia of Fabric Bands That Make Up Canopy (with respect to x-x and y-y axis).

The pitch and yaw mass moment of inertia can be shown to be

$$I_{x-x} = I_{y-y} = \sum^{n}[m_c r^4\{\pi\frac{\sin\theta_2}{3}(\cos^2\theta_2 + 2) - \frac{\sin\theta_1}{3}(\cos^2\theta_1 + 2)\}$$

$$+\frac{2}{3}\pi\{\sin^3\theta_2 - \sin^3\theta_1\}] \qquad (11\text{-}6)$$

For the 40-ft D_o ringsail parachute

$$I_{x-x} = I_{y-y} = 58.927 \text{ lb-ft-sec}^2 \qquad (11\text{-}7)$$

With respect to the parachute assembly c.g. axis

$$I_{\underline{X-X}} = I_{\underline{Y-Y}} = 58.927 + \frac{16.637}{32.2}(4.96)^2 = 71.75 \text{ lb-ft-sec}^2 \qquad (11\text{-}8)$$

11.3 Radial Bands

11.3.1 Roll Inertia of Radial Bands on a Canopy (with respect to z-z axis).

The roll mass moment of inertia of the radial bands can be shown to be

$$I_{z-z} = nm_b r^3 \{\frac{\theta_2-\theta_1}{2} + \frac{\sin 2\theta_2 - \sin 2\theta_1}{4}\} \qquad (11\text{-}9)$$

where n is the number of radial bands under consideration. The mass distribution, m_b, is the mass of the radial band per unit running length. Hence

$$m_b = \frac{W_b}{n\ g\ r\frac{\pi}{2}} \qquad (11\text{-}10)$$

For the 40 ft D_o ringsail parachute under consideration herein there are 36 radial bands. Hence

$$m_b = \frac{2\ (4.64)}{36(32.2)(13.591)(3.14)} = .188 \times 10^{-3}\ \frac{\text{lb sec}^2}{\text{ft}^2} \qquad (11\text{-}11)$$

Equation (11-9) when used for the 40 ft D_o ringsail yields

$$I_{z-z} = 13.10 \text{ lb-ft-sec}^2 \qquad (11\text{-}12)$$

<u>11.3.2 Pitch and Yaw Inertia of Radial Bands on a Canopy</u> (with respect to x-x and y-y axis).

The pitch and yaw mass moment of inertia can be shown to be

$$I_{x-x} = I_{y-y} = 4\sum_{1}^{p} m_b r^3 \left[\frac{\pi}{4} \sin^2\psi\left\{\frac{\theta_2-\theta_1}{2} + \frac{\sin 2\theta_2 - \sin 2\theta_1}{4}\right\} + \frac{\theta_2-\theta_1}{2} - \frac{\sin 2\theta_2 - \sin 2\theta_1}{4}\right] \qquad (11\text{-}13)$$

where, for the following,

p	ψ
1	10°
2	20°
3	30°
4	40°
5	50°
6	60°
7	70°
8	80°
9	90°

In the 40 ft D_o ringsail parachute

$$I_{x-x} = I_{y-y} = 19.75 \text{ lb-ft-sec}^2$$

The pitch and yaw mass moment of inertia with respect to the system's c.g. is

$$I_{X-X} = I_{Y-Y} = 19.75 + \frac{4.64}{32.2}(4.96)^2 = 22.29 \text{ lb-ft-sec}^2 \qquad (11\text{-}14)$$

11.4 Shroud Lines

11.4.1 Roll Inertia of Shroud Lines Making Up a Parachute (with respect to z-z axis).

The roll mass moment of inertia of a number of shroud lines can be shown to be

$$I_{z-z} = n\frac{m_s L^3}{3} \sin^2\alpha \tag{11-15}$$

where m_s is the mass distribution of the shroud line per running unit length. The number of shroud lines is designated n.

$$m_s = \frac{W_s}{n\ L\ g} \tag{11-16}$$

In the 40 ft D_o ringsail

$$m_s = \frac{8.05}{36(40)32.2} = .56 \times 10^{-3} \frac{\text{lb sec}^2}{\text{ft}^2} \tag{11-17}$$

Using equation (11-15) yields

$$I_{z-z} = 15.7 \text{ lb-ft-sec}^2 \tag{11-18}$$

11.4.2 Pitch and Yaw Inertia of Shroud Lines Making Up a Parachute (with respect to B-B and C-C axis).

The pitch and yaw inertia can be shown to be

$$I_{B-B} = I_{C-C} = 4 \sum^{p} [m_s L^3 \sqrt{\frac{\sin^2\alpha \sin^2\psi + \cos^2\alpha}{1-\sin^2\alpha \cos^2\psi}}$$

$$\{\frac{\sin^2\alpha\sin^2\psi}{3} + \frac{7}{12}\cos^2\psi - \frac{\cos\alpha}{2}\}] \tag{11-19}$$

Evaluating the above yields

$$I_{B-B} = I_{C-C} = 26.0 \text{ lb-ft-sec}^2 \tag{11-20}$$

With respect to the system's c.g.

$$I_{X-X} = I_{Y-Y} = 26.0 + \frac{8.05}{32.2}(14.8)^2 = 80.7 \text{ lb-ft-sec}^2 \tag{11-21}$$

11.5 Canopy Apron

11.5.1 Roll Inertia of Canopy Apron (with respect to z-z axis).

The standard expression applies here, and is

$$I_{z-z} = m_a r^2 \tag{11-22}$$

where m_a is the total mass of the apron.

$$m_a = \frac{2.31}{32.2} = .072 \frac{\text{lb sec}^2}{\text{ft}} \tag{11-23}$$

Hence,

$$I_{z-z} = 11.19 \text{ lb-ft-sec}^2 \tag{11-24}$$

11.5.2 Pitch and Yaw Inertia of Canopy Apron (with respect to x-x and y-y axis).

The standard expression is

$$I_{x-x} = I_{y-y} = \frac{m_a}{2} (r^2 + \frac{h^2}{6}) \tag{11-25}$$

Hence,

$$I_{x-x} = I_{y-y} = 6.6 \text{ lb-ft-sec}^2 \tag{11-26}$$

With respect to the system's c.g.

$$I_{X-X} = I_{Y-Y} = 6.6 + \frac{2.31}{32.2} (4.93)^2 = 8.3 \text{ lb-ft-sec}^2 \tag{11-27}$$

TABLE 11-3

Summary

Member	I_{z-z} (lb-ft-sec^2)	$I_{X-X} = I_{Y-Y}$ (lb-ft-sec^2)
Canopy rings	73.197	71.75
Radial bands	13.10	22.29
Shroud lines	15.70	80.7
Canopy apron	11.19	8.3

12.0 FABRICATION AND PACKING

12.1 Fabrication

The parachute-fabrication sequence was as follows.

(a) Cut cloth and stamp ring or sail number in upper-righthand corner.

(b) Baste rings or sails together down main seams, forming a series of complete rings from vent to skirt.

(c) Attach circumferential reinforcing tapes to leading and trailing edges of rings and sails.

(d) Make skirt and vent hems.

(e) Mark radial tapes with ring and sail positions and cut.

(f) Sew cotton loop buffer to radial tapes, folding the radial, ready for suspension-line-attachment loop formation.

(g) Attach radial tapes, starting at the vent, matching marks to ring and sail edges. Insert the radial-gap-reinforcement tape through the gap and form the suspension-line-attachment loop when the skirt is reached.

(h) Add two-point cross stitching to radial at vent, skirt, and top and bottom of the gap.

(i) Mark and cut suspension lines per instructions on drawing 1.419.

(j) Attach suspension lines to suspension-line-attachment loops and zig-zag stitch.

(k) Attach other end of suspension lines to attached riser, and close riser ends.

The parachute itself is now complete except for gore numbering and for stamping of manufacturing data on gore 1.

12.2 PACKING PROCEDURE FOR 40-ft RING-SAIL ASSY. #19.1464

1. Verify that canopy S/N, deployment bag S/N, and assy S/N are the same, and record on log sheet. (Use Form E-0067-AT/4A.)

2. Verify that Pioneer and Martin inspection stamps are on canopy, on bag flap, and adjacent to assy S/N on bag.

3. Stretch canopy and suspension lines under tension. (See photo #1.)

4. Pleat canopy gores, 18 to each side, with #1 gore up.

5. Verify that post reefing-line lengths are equal, that red ends match red ends, that blue ends match blue ends, and that splices match splices.

6. Relieve tension in canopy.

7. Check reference marks of splice at skirt to assure proper lengths. (Splice must not be located in canopy. Should be like detail on Dwg. 19.1464.)

8. Retension canopy.

9. Temporarily tack one post reefing line at mid gore #5, and flag.

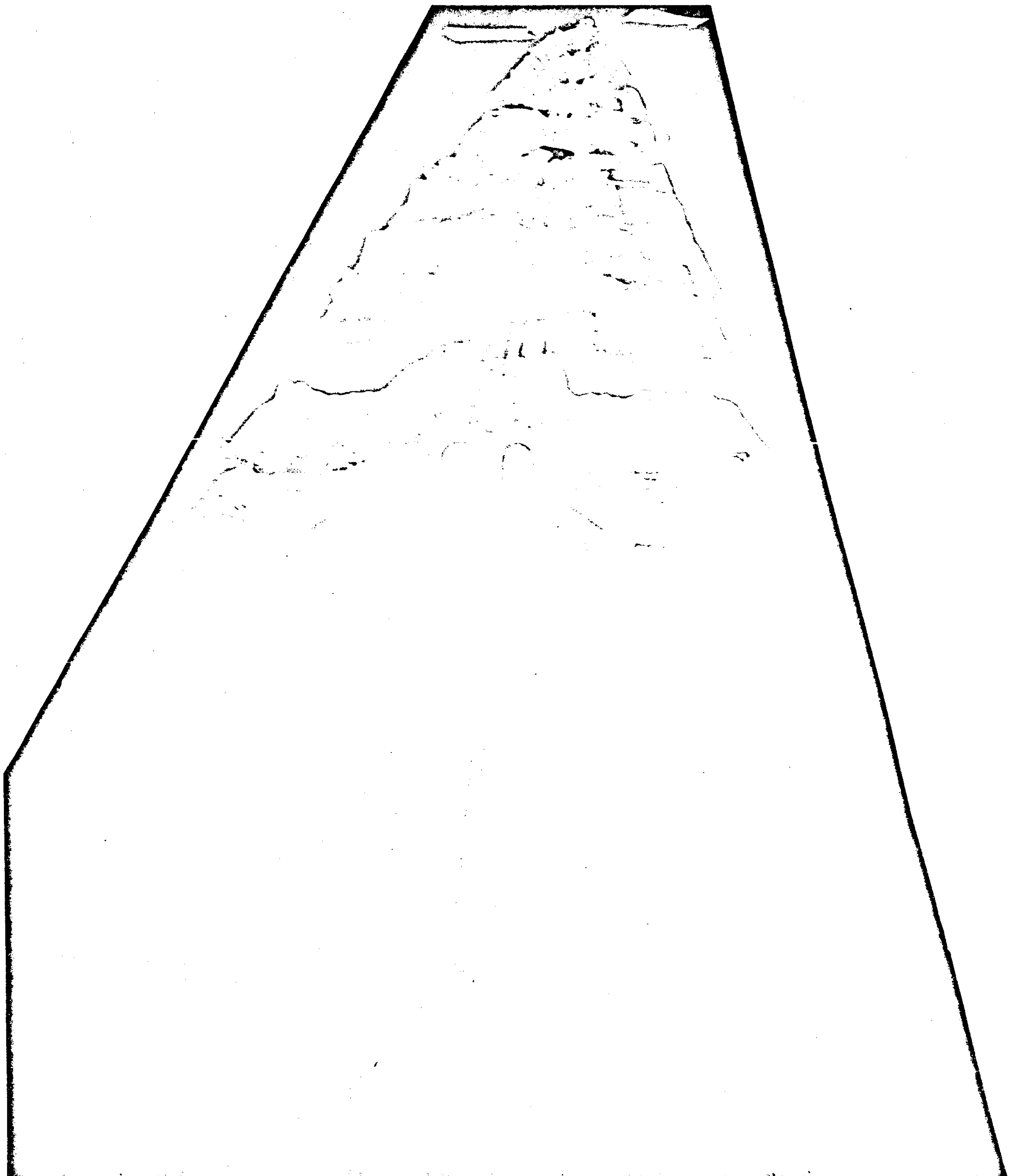
10. Feed red end of line through rings #5 through #32, and tie on ring #32.

11. Feed blue end of line through rings #6 through #14, and tie on ring #14.

12. Temporarily tack post reefing line at mid gore #23, and flag.

13. Feed red end of line through rings #23 through #14, and tie on #14.

14. Feed blue end of line through rings #24 through #32, and tie on #32.



Photograph Number 1

15. Check each tie-off to assure propoer serving and excess end removal. (See Detail B, Dwg. 19.1464.)

16. With Dacron "F" thread, tack post reefing line at skirt per print. (Ref. Dwg. 19.1464.)

17. Install 6-cord Dacron tie (approx. 7 ft long) to loop in bottom inside of bag. (Use bowline knot.)

18. Install balsa wood block in deployment bag, and record block weight. (Use Form E-0067-AT/4A.)

19. Check weight of bag and block, and record weight. (Use Form E-0067-AT/4A.)

20. Repleat canopy gores, and fold in post reefing lines.

21. Attach 6-cord Dacron tie from bag to apex. (Use bowline knot.)

22. Relieve tension.

23. Remove temporary tacks and flags from mid gores #5 and #23.

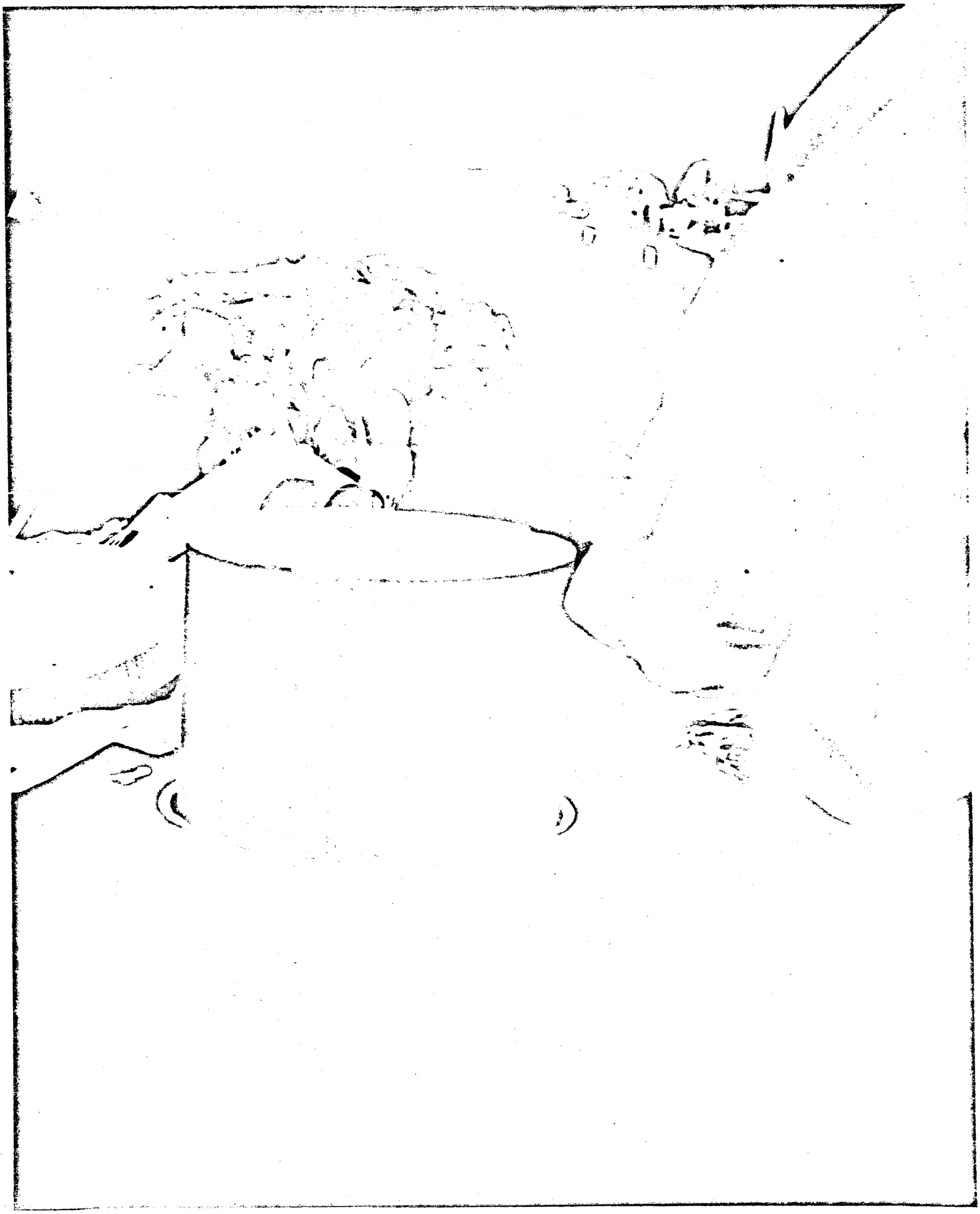
24. Gather suspension lines into bundles approximately 10½ in. long and hold with rubber bands. (See photo #2.) Place filler block in bottom of packing container. (See photo #3.) Place bag in packing container, and secure with 550-lb cord. (See photo #4.)

25. Fold panels #1 through #8 into bag and put under pressure. (See photo #5.)

26. Relieve pressure, fold in panel #10, and reapply pressure.

27. Relieve pressure, fold in panel #11, and reapply pressure. (See photo #6.)

Photograph Number 2



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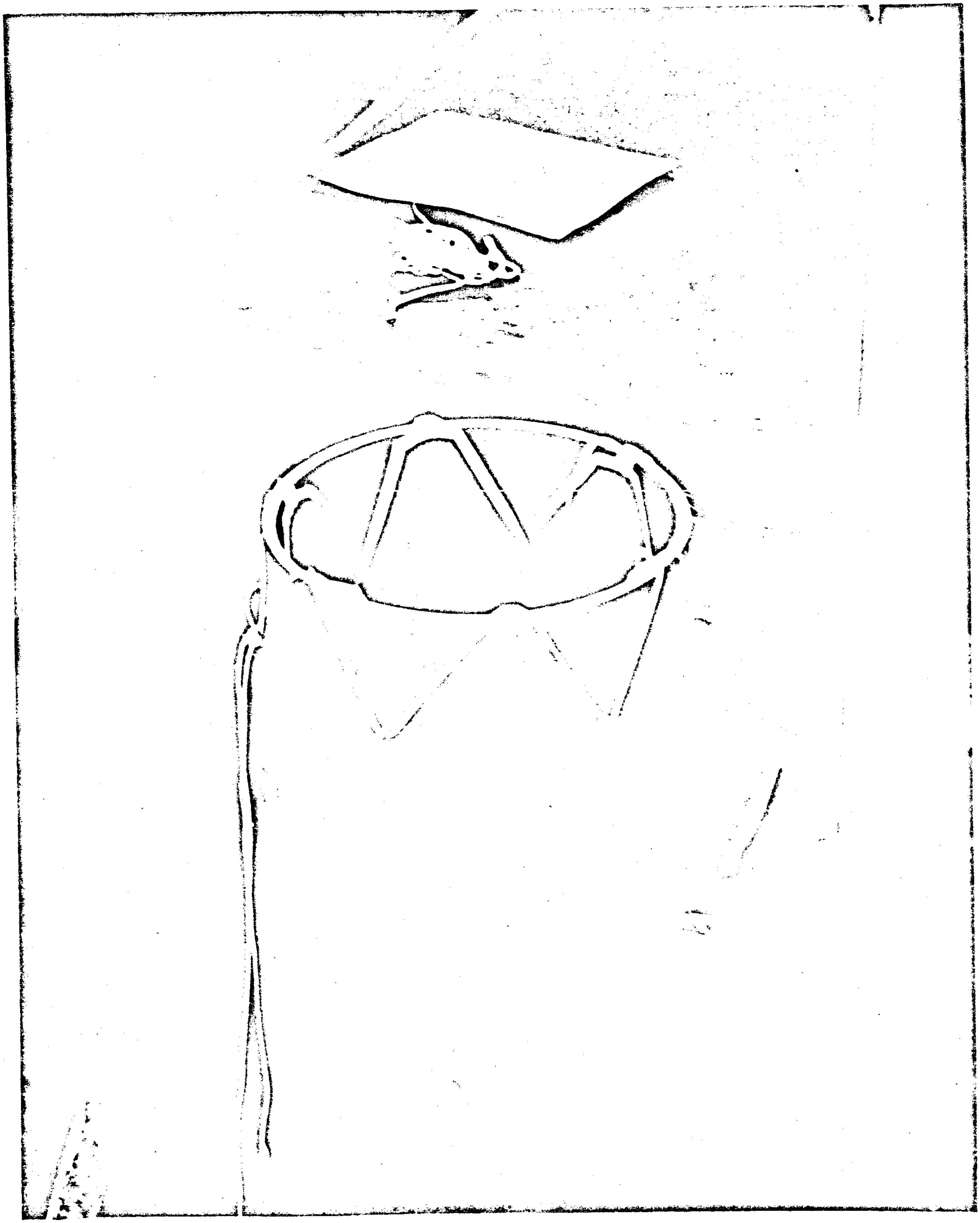

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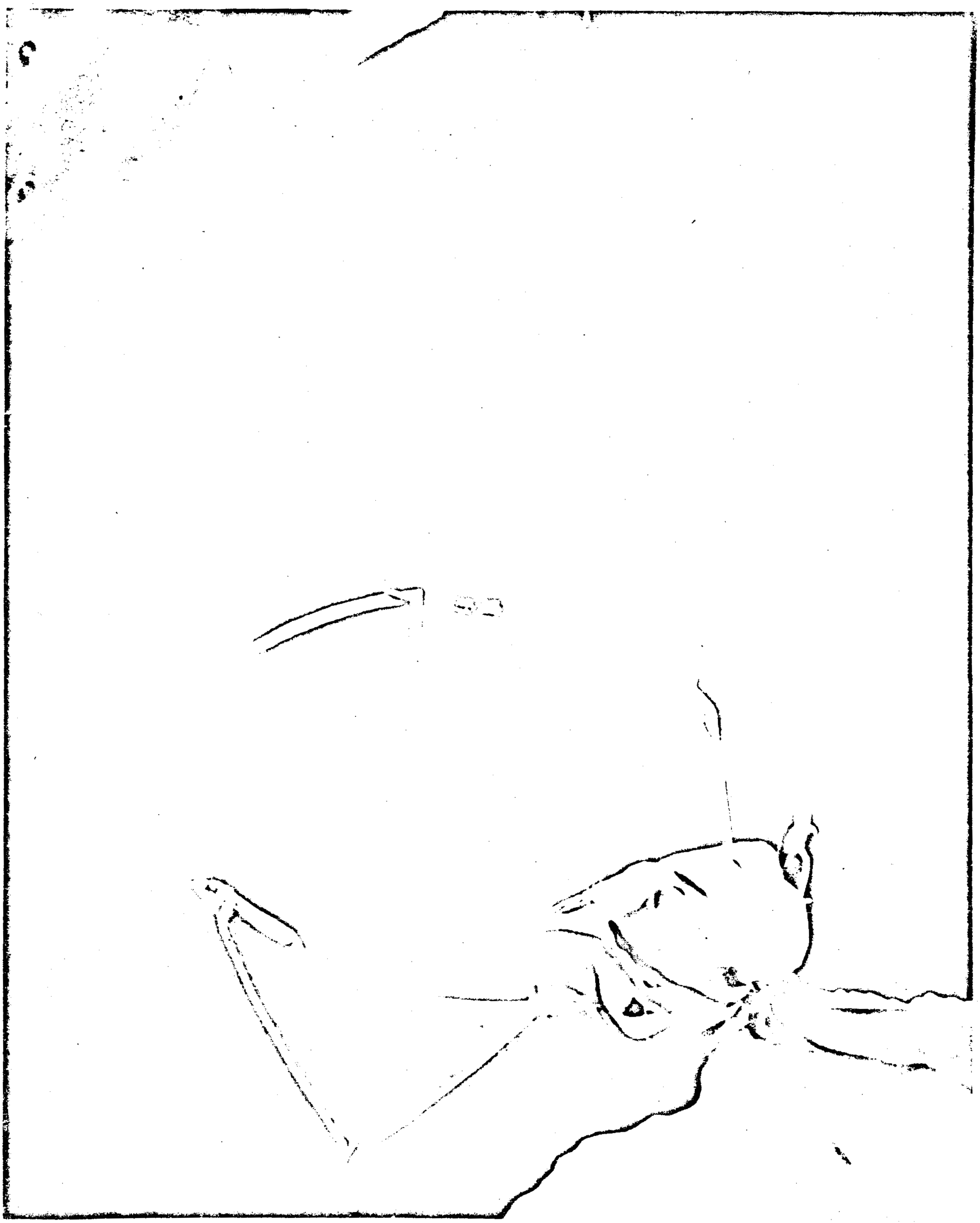

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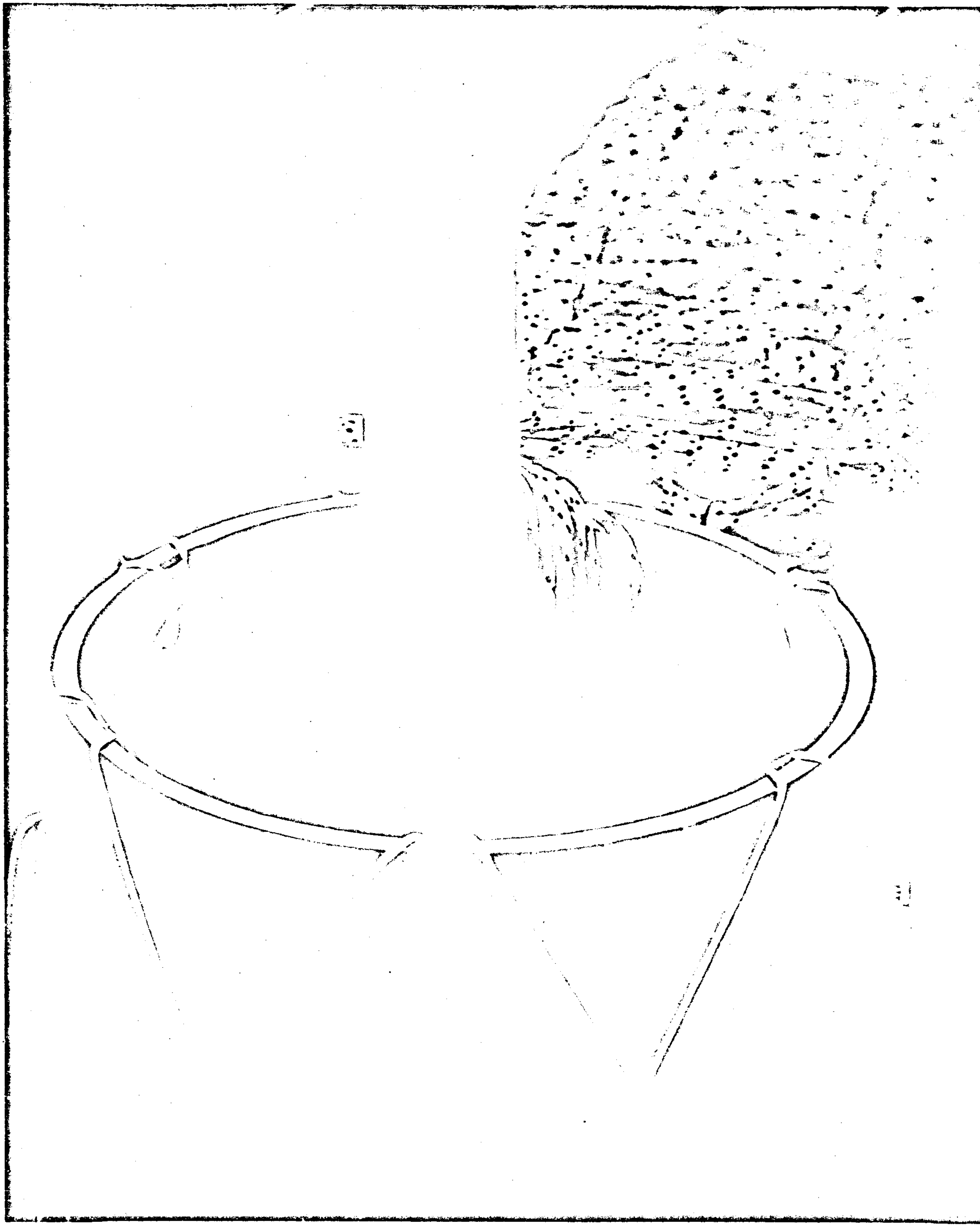


Photograph Number 6

28. Relieve pressure.

29. Lay in one level of bundled suspension lines. Remove rubber bands from laid-in level.

30. Lay in next level of bundled suspension lines at right angles to previous level. Remove rubber bands from laid-in level. (See photo #7.)

31. Repeat step 30 until all levels are completed.

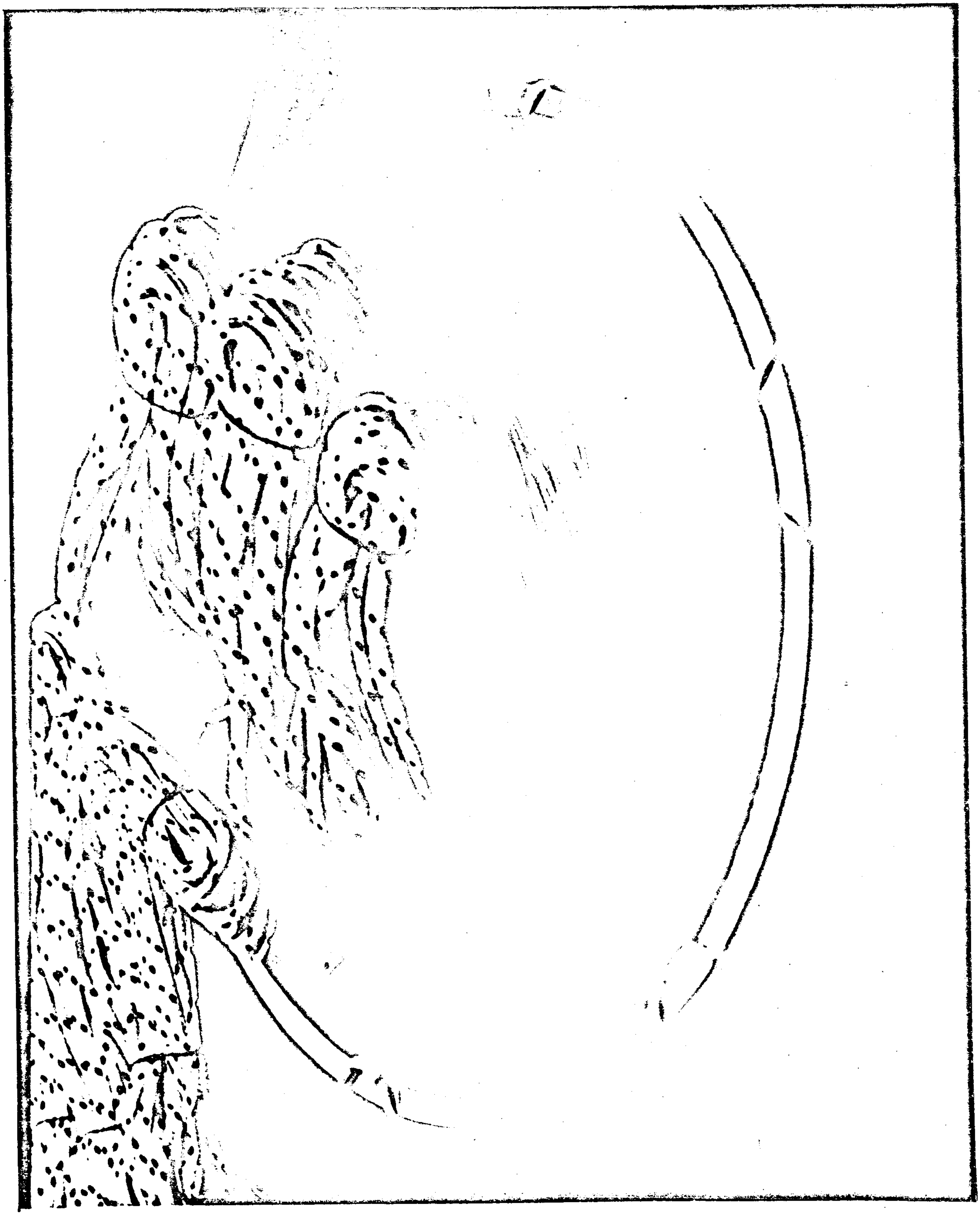
32. Reapply pressure.

33. Fold in riser portion of canopy to cutter knife, and tie bag mouth with 550-lb Nylon cord sleeve, and attach red flag. (Use slip knot with locking loop.) (See photo #8.)

34. Feed 300-lb Dacron cord through mouth ties, and rig cutter knife.

35. Fold in excess riser. (See photo #9.)

36. Install lid and retaining bolts.



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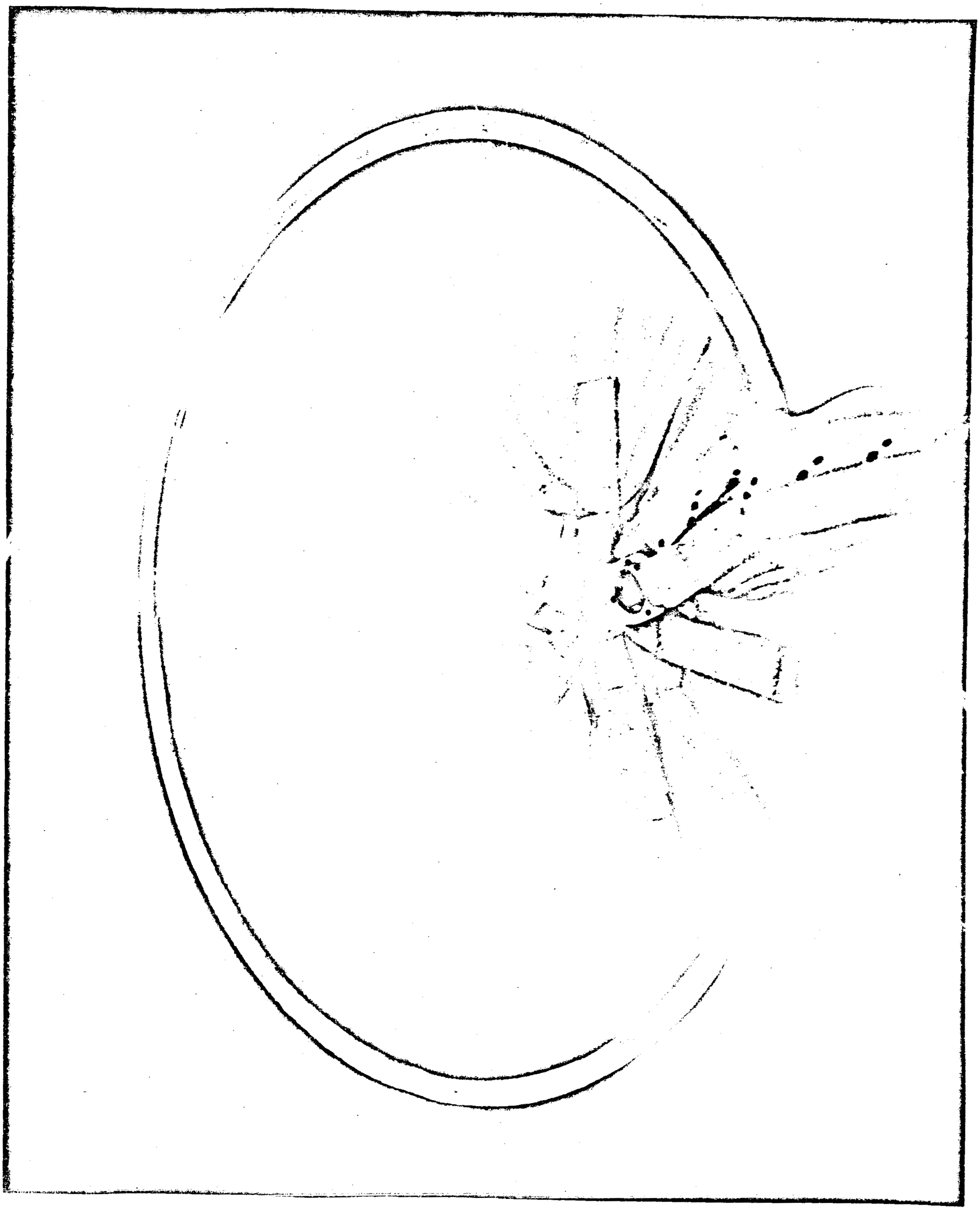

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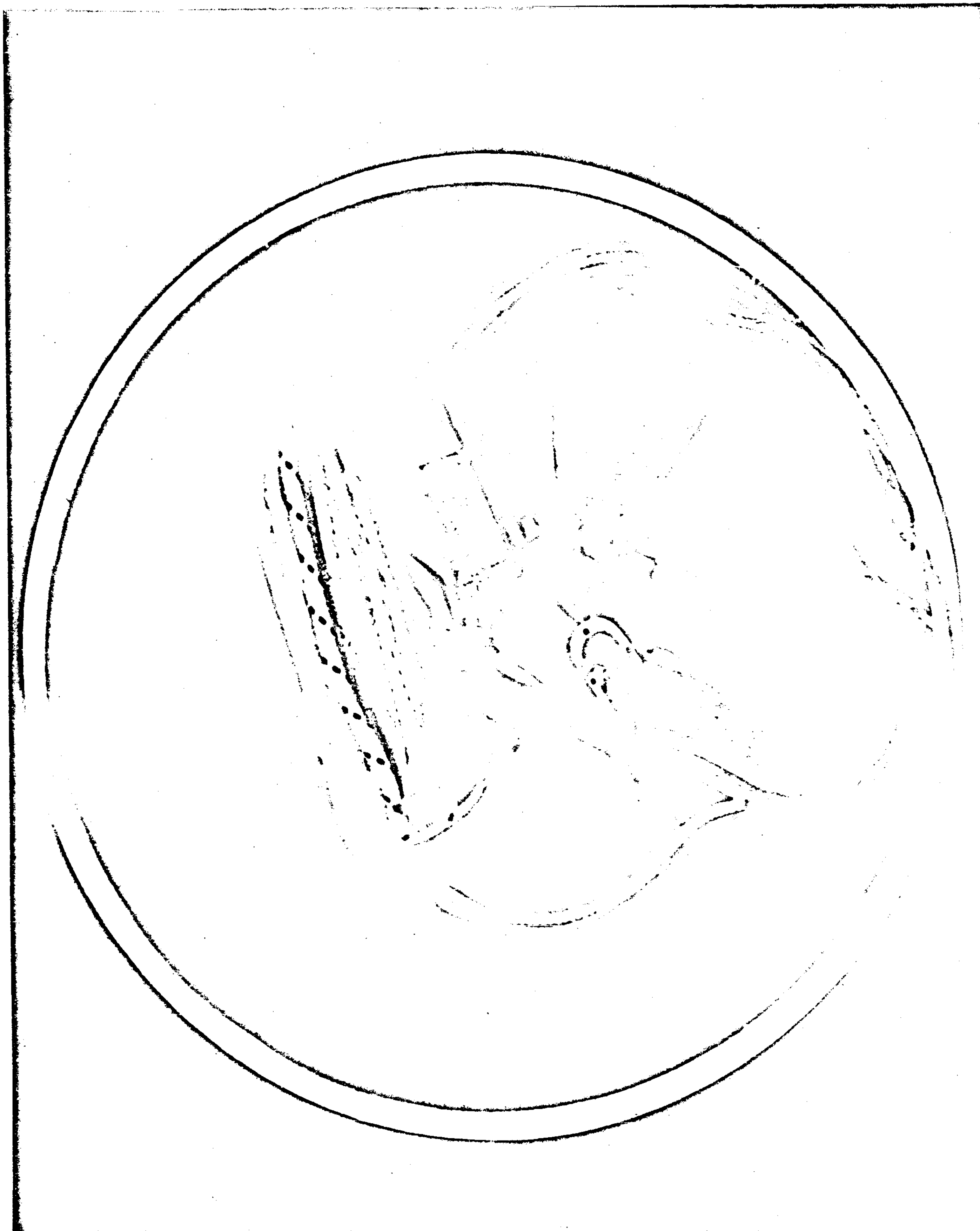


Photograph Number 9

APPENDIX A

Computer Run for Opening Force

PIONEER PARACHUTE CO., INC. TWO DEGREE OF FREEDOM TRAJECTORY PROGRAM, POINT MASS, FLAT, NON-ROTATING EARTH. 10/65
E-0067.
40-FT. RINGSAIL PARACHUTE.

CASE NO.	CD*S	VSUBO	QSUBO	INF. TIME	MACH
5015 -1	754 SQ.FT.	1650FPS	12.0FPS	0.35 SEC.	1.6

TIME SEL.	CL1	CD1	CL2	CD2	CL3	CD3	CL4	CD4	TL	TD	WEIGHT	PRINT INT
.00	.00	1.17	.00	.00	.00	.00	.00	.00	.00	.00	240.00	.05
.05	.00	1.17	.00	10.00	.00	.00	.00	.00	.00	.00	240.00	.05
.10	.00	1.17	.00	40.00	.00	.00	.00	.00	.00	.00	240.00	.05
.15	.00	1.17	.00	87.00	.00	.00	.00	.00	.00	.00	240.00	.05
.20	.00	1.17	.00	160.00	.00	.00	.00	.00	.00	.00	240.00	.05
.25	.00	1.17	.00	300.00	.00	.00	.00	.00	.00	.00	240.00	.05
.30	.00	1.17	.00	500.00	.00	.00	.00	.00	.00	.00	240.00	.05
.35	.00	1.17	.00	754.00	.00	.00	.00	.00	.00	.00	240.00	.05
1.00	.00	1.17	.00	754.00	.00	.00	.00	.00	.00	.00	240.00	.05

MACH NO.	CLM1	CDM1	CLM2	CDM2	CLM3	CDM3	CLM4	CDM4
.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

T0=	.00 SEC.	S1=	1.00 SQ. FT.	INTEGRATION INT.=	.05
R0=	.00 FT.	S2=	1.00 SQ. FT.		
V0=	1650.00 FT./SEC.	S3=	1.00 SQ. FT.		
H0=	128300.00 FT.	S4=	1.00 SQ. FT.		
GAM0=	40.00 DEG.	HS=	.00 FT.		
		TS=	1.00 SEC.		

TIME	VELOCITY	ACCELERATION	ALTITUDE	RATE OF CLIMB	DYNAMIC PRESSURE	PATH ANGLE	MACH NO.	RANGE	L2	L3	L4
.0	1650.00	-22.56	128300.00	1060.43	12.00	39.99	1.56	.00	.0	.0	.0
.0	1648.87	-38.56	128353.02	1058.76	11.95	39.95	1.56	63.20	119.5	.0	.0
.1	1646.95	-86.31	128405.96	1056.58	11.90	39.91	1.56	126.37	476.0	.0	.0
.1	1642.64	-160.21	128458.79	1052.87	11.81	39.86	1.55	189.41	1027.5	.0	.0
.2	1634.66	-272.72	128511.43	1046.81	11.67	39.82	1.55	252.19	1867.0	.0	.0
.2	1621.13	-462.89	128563.77	1037.20	11.45	39.78	1.53	314.48	3435.1	.0	.0
.3	1597.33	-765.78	128615.63	1021.03	11.09	39.73	1.51	375.90	5545.8	.0	.0
.3	1559.91	-1089.09	128666.68	996.17	10.55	39.69	1.47	435.92	7958.3	.0	.0
.4	1507.26	-1016.00	128716.49	961.60	9.83	39.64	1.43	493.95	7414.8	.0	.0
.4	1458.08	-950.15	128764.57	929.29	9.18	39.59	1.38	550.13	6923.7	.0	.0
.5	1412.04	-890.60	128811.03	899.01	8.59	39.54	1.33	604.58	6480.4	.0	.0
.5	1368.85	-836.56	128855.98	870.56	8.06	39.49	1.29	657.39	6078.1	.0	.0
.6	1328.23	-787.38	128899.51	843.79	7.58	39.44	1.26	708.68	5712.0	.0	.0
.6	1289.96	-742.49	128941.70	818.53	7.13	39.39	1.22	758.53	5377.8	.0	.0
.7	1253.85	-701.39	128982.62	794.67	6.73	39.33	1.18	807.02	5072.0	.0	.0
.7	1219.71	-663.68	129022.36	772.08	6.35	39.27	1.15	854.23	4791.3	.0	.0
.8	1187.38	-628.99	129060.96	750.66	6.01	39.21	1.12	900.23	4533.1	.0	.0
.8	1156.72	-596.99	129098.49	730.32	5.70	39.15	1.09	945.08	4295.0	.0	.0
.9	1127.59	-567.43	129135.01	710.98	5.40	39.09	1.07	988.84	4075.0	.0	.0
.9	1099.89	-540.05	129170.56	692.56	5.13	39.03	1.04	1031.57	3871.3	.0	.0
1.0	1073.51	-515.39	129205.18	674.99	4.88	38.96	1.01	1073.30	3682.3	.0	.0

APPENDIX B

Joint Test Data

LABORATORY JOINT TEST REPORTS

This appendix presents the results of laboratory strength-of-materials and structural-integrity tests required by Para. 1.15 of the Work Statement for Martin Marietta Contract MC7-709025, Amendment 1.

The tests reported on here were made to ascertain the adequacy of the primary structural (and in some cases the secondary structural) members of the parachute assembly, Pioneer dwg. 19.1464. The style and format of these reports are in accordance with parachute-industry standard technology.

Figure 1 and Table 1 are furnished as a guide to locating specific tests. Refer to either Fig. 1 or Table 1 to obtain a slash number for the test area desired. Test reports follow Table 1 in numerical order. If an illustration accompanies a report, it bears the same identifying number as the report.

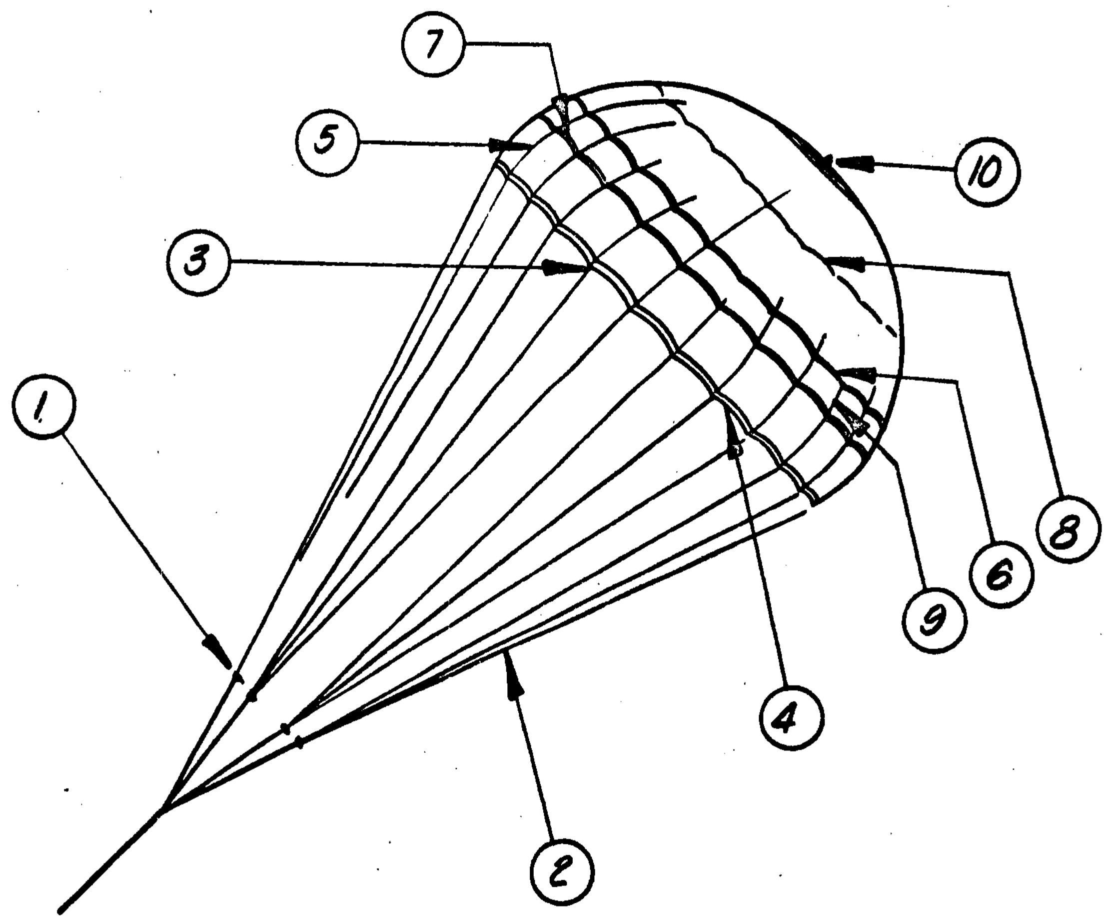


Figure 1. Key to laboratory-test reports, E-0067-TL series, for ringsail parachute 1.419.

TABLE 1
LABORATORY TEST REPORTS, E-0067-TL SERIES

Test no. E-0067-TL/	Item(s) tested
1	Joint, suspension line to webbing
2	Suspension line Spec E-0067-1
3	Joint, suspension line to loop attachment
4	Hem, skirt band
5	Seam, main
6	Hem, gap reinforcement and bottom of sail
7	Hem, top of sail
8	Hem, top of rings
9	Tape, radial, w/reinforcing band
10	Band, vent

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED	PROJECT NO. E-0067
Joint, suspension line to webbing Ref. dwg. no. 1.419, sheet 2. Detail G	TEST NO. E-0067-TL-1

PURPOSE [x] ULTIMATE STRENGTH [x] POINT OF FAILURE [x] EFFICIENCY [ ] OTHER

TEST METHOD Use Tinius Olsen testing machine, 1200-lb scale, with 12-in./min. load rate. Fabricate and pull 3 samples per attached sketch.

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB		JPB	

TABLE

Sample	Ult. strength, lb
1	5330
2	5170
3	5290
Av.	5263 or 91.6%

COMMENTS

1. All specimens failed at point indicated on attached sketch.
2. Theoretical ultimate strength of weakest member is 5733 lb (9 cords × 637 lb av. str.).
3. See test no. E-0067-TL/2 for details of 637-lb av. ult. strength.
4. Rated strength is ultimate strength of weakest member = 4950 (9 cords x 550 rated ult. str.)

RESULTS AND CONCLUSIONS

1. First estimate of joint efficiency was 93% based on test results from similar application. (Previous tests were on old Tinius Olsen Machine.) These tests were conducted using new machine.

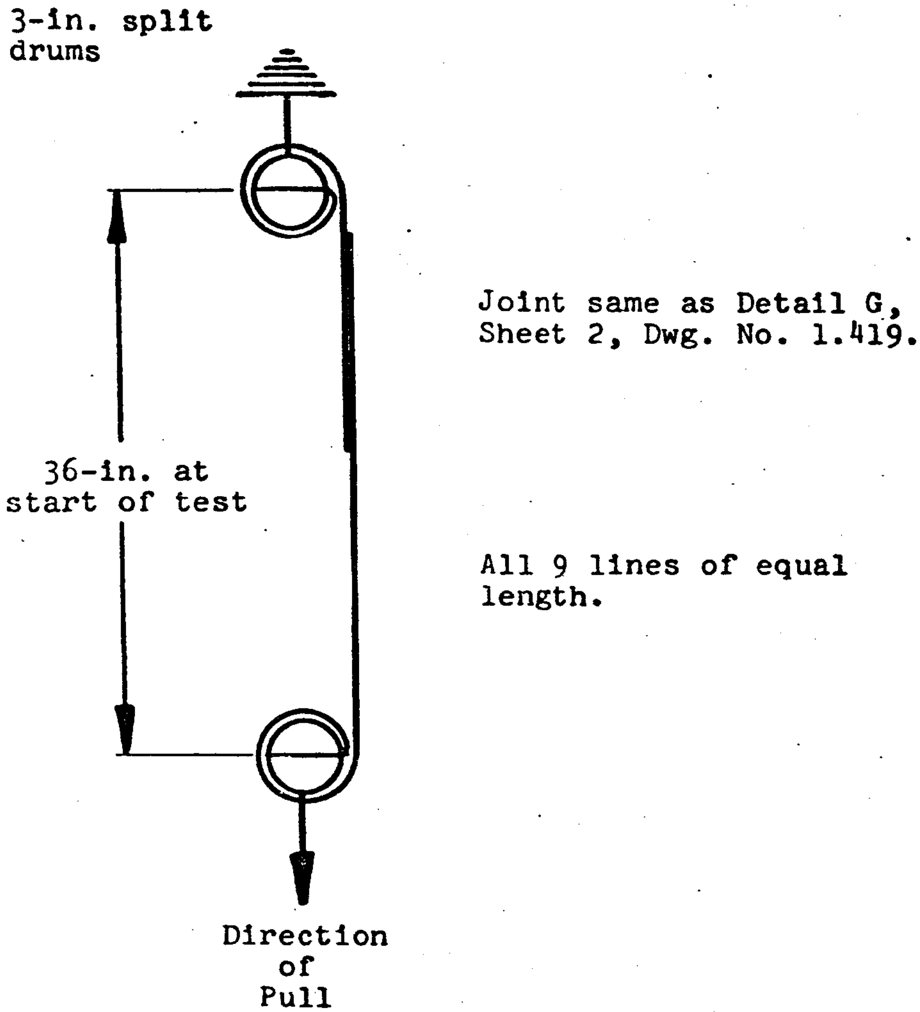
2. Efficiency of joint is (av. ult. str. of joint)/(av. ult. str. of weakest member)=(5263 lb)/(5733 lb) = 91.6%.

3. or efficiency is (min. ult. str.)/(rated str.) = (5170 lb)/(4950 lb) = 104%.

GENERAL REMARKS

Although the actual joint efficiency is less than anticipated by using actual efficiency, we are still able to maintain a positive margin of safety.

TESTED BY J.P. Brecht	DATE COMPLETED



Joint, Suspension Line to Webbing

Sketch E-0067-TL/1

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Suspension line spec E-0067-1	PROJECT NO. E-0067 TEST NO. E-0067-TL/2

PURPOSE [x] ULTIMATE STRENGTH [ ] POINT OF FAILURE [ ] EFFICIENCY [ ] OTHER

TEST METHOD Similar to Federal Specification CCC-T-191b, Method 4102, except min. 3 samples per spool and report to nearest pound.

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB		JPB	

TABLE

Ult. strength, lb

Piece	Roll 601	602	603	604	605	606
1	620	648	650	620	652	640
2	638	610	658	640	640	640
3	630	615	658	640	642	636
4	640					
5	632					
6	620					
Av/roll	630	624	655	633	644	638

Av for total lot = 637

RESULTS AND CONCLUSIONS

All failures occurred over min. ultimate rated strength.

GENERAL REMARKS

Test samples were taken from material bought on Purchase Order 39651.

TESTED BY J. P. Brecht	DATE COMPLETED

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED	PROJECT NO. / TEST NO.
Joint, suspension line to loop attachment. Ref. dwg. no. 1.419 Detail A.	PROJECT NO. E-0067 TEST NO. E-0067-TL/3

PURPOSE [x] ULTIMATE STRENGTH [x] POINT OF FAILURE [x] EFFICIENCY [ ] OTHER

TEST METHOD Use Tinius Olsen testing machine, 2400-lb scale, with 12-in./min. load rate. Similar to Federal Specification CCC-T-191b, Method 4102, except fabricate and pull 4 samples per attached sketch.

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB		JPB	

TABLE

Sample	Ult. strength, lb
1	614
2	632
3	620
4	614
Av.	620 or 97%

COMMENTS

Average ult. strength of weakest member (suspension line) is 637 lb - See test no. E-0067-TL/2 for details.

(See attached sketch for zone of failure.)

RESULTS AND CONCLUSIONS

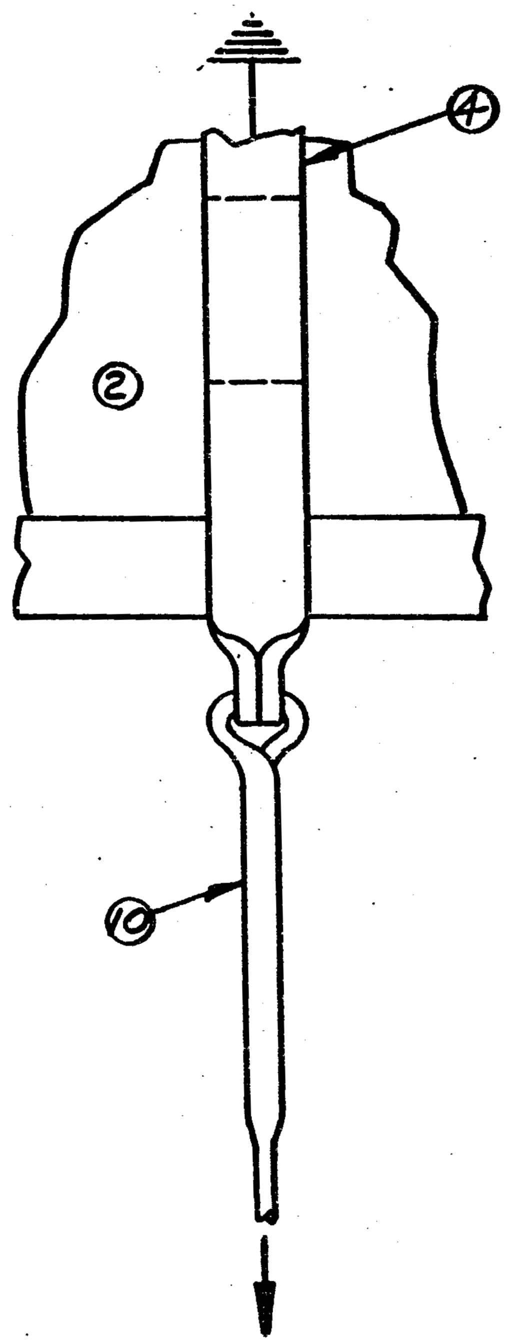
1. Efficiency of joint is (av. ult. str. of joint)/(av. ult. str. of weakest member)=(620 lb)/(637 lb) = 97%.

2. Efficiency of joint is (min. ult. t.s. of joint)/(min. ult. t.s. of weakest member) = (614 lb)/(610 lb) = 100+.

GENERAL REMARKS

Joint is acceptable for application intended and meets strength requirements.

TESTED BY	DATE COMPLETED
J. P. Brecht	



See dwg. 1.419 for details of materials and joining

Joint-suspension line to loop attachment
Sketch E-0067-TL/3

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED Hem, skirt band, see dwg. 1.419 Detail C for details.	PROJECT NO. E-0067 TEST NO. E-0067-TL/4

PURPOSE [x] ULTIMATE STRENGTH [ ] POINT OF FAILURE [ ] EFFICIENCY [ ] OTHER

TEST METHOD Use Tinius Olsen testing machine, 2400-lb range, with 12-in./min. load rate. Test similar to Federal Specification CCC-T-191b, Method 4102, except fabricate and pull 3 samples per attached sketch. (Use 3 in. split jaw.)

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB	4/6/67	JPB	4/6/67

TABLE

Sample	Ult. strength, lb
1	552
2	560
3	562
Av.	558 or 98%

COMMENTS
Dacron tape spec 66-5 Type II control samples were from roll #601.

(Av. ult. str. of 3 control samples was 570 lb.)

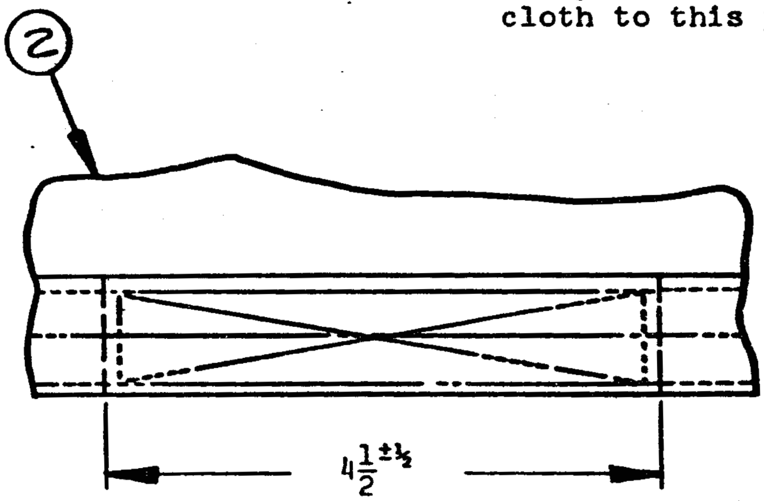
RESULTS AND CONCLUSIONS

1. Efficiency of joint is (av. ult. str. of joint)/(av. ult. str. of reinforcing tape)=(558 lb)/(570 lb) = 98%.

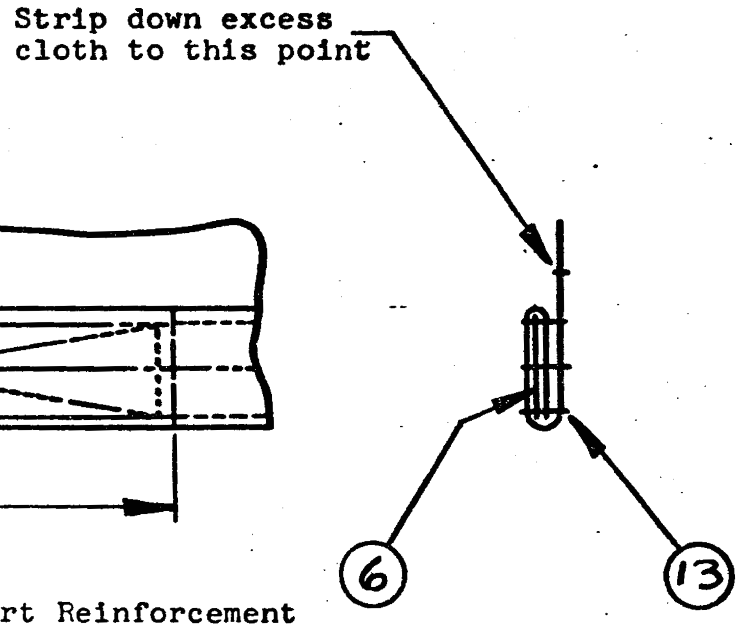
2. Ultimate strength of the hem is within predicted value and is acceptable.

GENERAL REMARKS

TESTED BY	DATE COMPLETED
J. P. Brecht 4/7/67	



Overlap of Skirt Reinforcement
See Note 15



Detail C, Dwg. 1.419

Hem, Skirt Band
Sketch E-0067-TL/4

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED	PROJECT NO. E-0067
Seam, main 40-ft Ringsail. Ref. dwg. no. 1.419, Sheet 1, Section Z-Z.	TEST NO. E-0067-TL/5

PURPOSE [x] ULTIMATE STRENGTH [ ] POINT OF FAILURE [x] EFFICIENCY [ ] OTHER

TEST METHOD Similar to Federal Specification CCC-T-191b, Method 5100, except 4 samples to be fabricated and pulled per attached sketch. Use Scott Serigraph, Model J3, 110-lb-capacity test machine.

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB	4/3/67	JPB	4/3/67

TABLE

Sample	Ult. strength, lb
1	24.0
2	20.5
3	28.5
4	25.0
Av.	24.5 for 1-in. test section.

COMMENTS

1. This main seam is the same as used on 84-ft Ringsail except radial tape is 550-lb min. ult. strength rather than 300-lb min. ult. strength. (See dwg. no. 1.562 Section Z-Z.)

RESULTS AND CONCLUSIONS

1. Average ultimate strength of control sample of cloth is 36 lb/in.

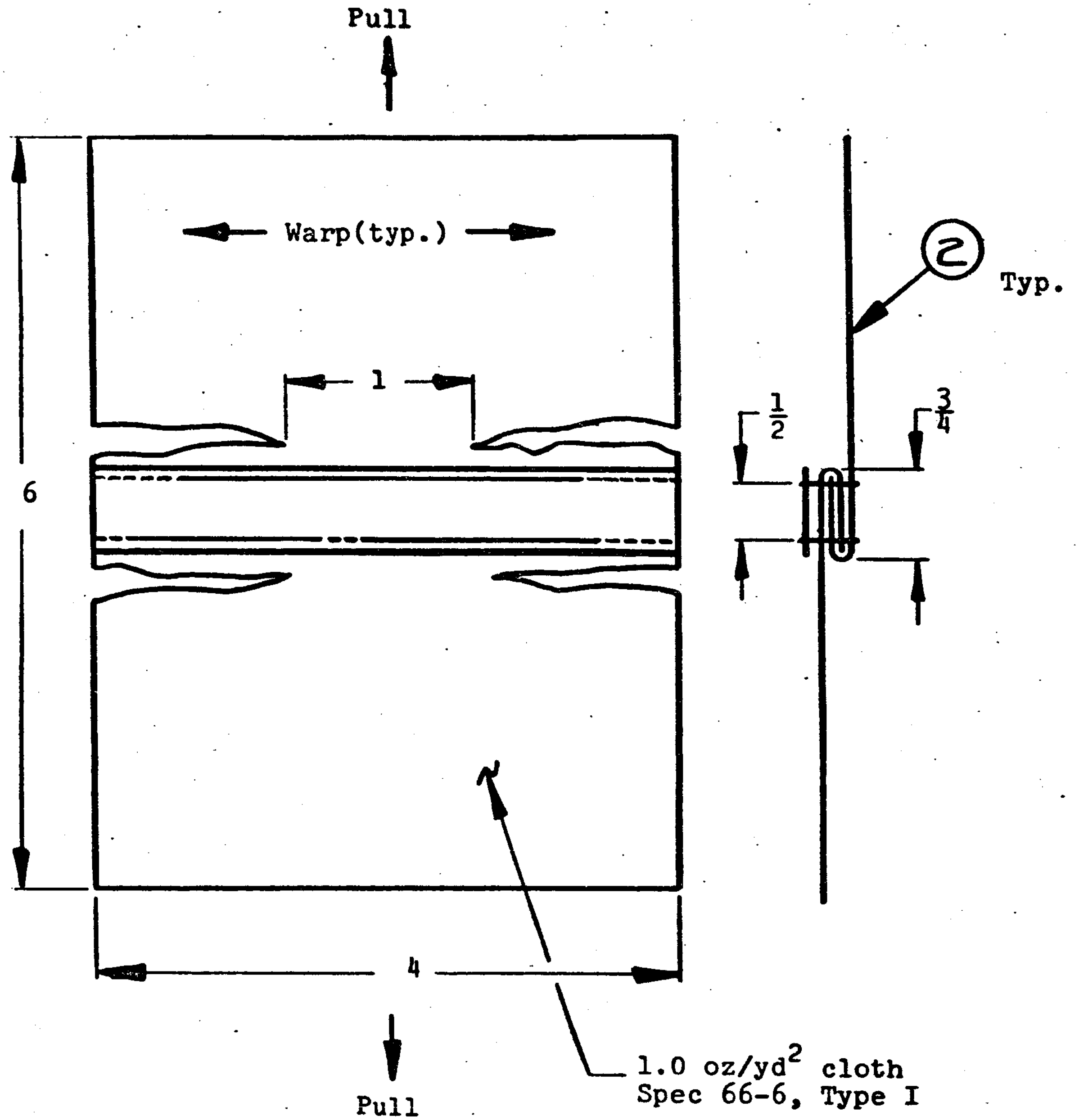
2. Efficiency of joint is (av. ult. str. of joint)/(av. ult. str. of cloth)=(24.5 lb)/(36 lb) = 68%.

3. Efficiency of joint is greater than predicted value and is acceptable for this type construction.

GENERAL REMARKS

1. Test samples from cloth material bought on P.O. 39634.

TESTED BY	DATE COMPLETED
Bayles, LaRiviere & Brecht 5/19/66, 9/30/66 and reverified 4/27/67	



NOTES:

1. Stitch with E thd V-T-285 7 to 11 st/in.
2. Make 4 samples from a single piece 24-in. long.

Seam, Main
Sketch E-0067-TL/5

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED	PROJECT NO. E-0067
Hem, gap reinforcment and bottom of sail. See dwg. 1.419, Section X-X.	TEST NO. E-0067-TL/6

PURPOSE [x] ULTIMATE STRENGTH [ ] POINT OF FAILURE [x] EFFICIENCY [ ] OTHER

TEST METHOD Similar to Federal Specification CCC-T-191b, Method 4102, except fabricate and pull 3 samples per attached sketch. Use Tinius Olsen testing machine, 600-lb range, with 12-in./min. load rate, and 3 in. split drums.

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB		JPB	

TABLE

Sample	Ult. strength, lb S/N 506025	Ult. strength, lb S/N 506026
1	296	294
2	292	290
3	290	296
Av.	292	292+

COMMENTS

1. Dacron tape spec 66-5 Type I, control samples were from roll #110 (av. ult. strength of 3 control samples was 308 lb*.
2. No apparent strength difference between construction of S/N 506025 or 506026.

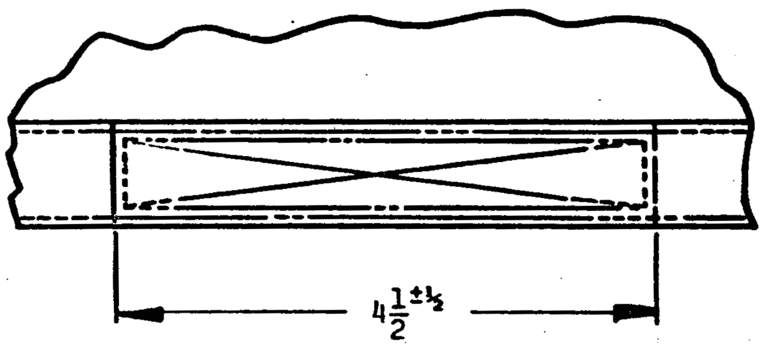
RESULTS AND CONCLUSIONS

1. Efficiency = (av. ult. str. of joint)/(av. actual str. of tape) = (292 lb)/(308 lb) = 95%.

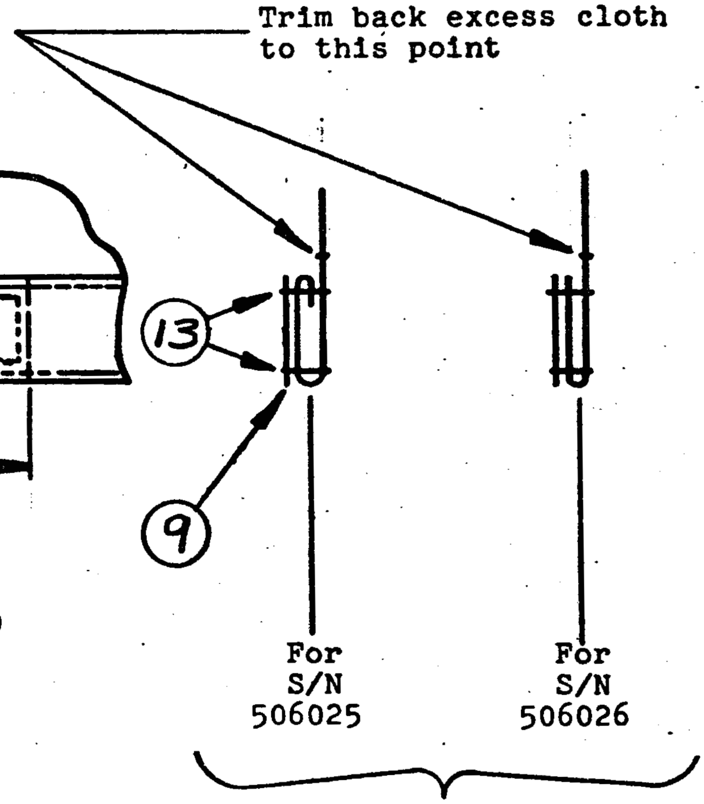
2. Joint efficiency is within predicted value and is acceptable for application intended.

GENERAL REMARKS

TESTED BY	DATE COMPLETED



Overlap of Skirt Reinf.
See Note 15, Dwg. 1.419



Section Z-Z

Joint hem, gap reinforcement
Sketch E-0067-TL/6

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED	PROJECT NO. E-0067
Hem, top of sail, see dwg. no. 1.419, Section Y-Y.	TEST NO. E-0067-TL/7

PURPOSE [x] ULTIMATE STRENGTH [ ] POINT OF FAILURE [x] EFFICIENCY [ ] OTHER

TEST METHOD Same as Federal Specification CCC-T-191b, Method 4102, except fabricate and pull 3 samples per attached sketch. Use Tinius Olsen testing machine, 600-lb range, with 12-in./min. load rate, and 3 in. split drums.

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB	4/14/67	JPB	4/14/67

TABLE

Sample	Ult. strength, lb
1	292
2	294
3	292
Av.	292+

COMMENTS

1. Dacron tape spec 66-5 Type I, control samples were from roll #110 (av. ult. strength of 3 control samples was 308 lb).

RESULTS AND CONCLUSIONS

1. Efficiency = (av. ult. str. of joint)/(av. actual str. of tape) = (292 lb)/(308 lb) = 95%.

2. Joint efficiency is within predicted values and is acceptable for application intended.

GENERAL REMARKS

TESTED BY J. P. Brecht 4/14/67 DATE COMPLETED

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED	PROJECT NO. E-0067
Hem, top of rings, see dwg. no. 1.419, Section X-X.	TEST NO. E-0067-TL/8

PURPOSE [x] ULTIMATE STRENGTH [ ] POINT OF FAILURE [x] EFFICIENCY [ ] OTHER

TEST METHOD Same as Federal Specification CCC-T-191b, Method 4102, except fabricate and pull 3 samples per attached sketch. Use Tinius Olsen testing machine, 600-lb range, with 12-in./min. load rate, and 3 in. split drums.

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB		JPB	

TABLE

Sample	Ult. strength, lb
1	554
2	562
3	560
Av.	560

COMMENTS

1. Dacron tape spec 66-5 Type II, control sample taken from roll #601 (av. ult. strength of 3 control samples was 570 lb).

RESULTS AND CONCLUSIONS

1. Efficiency of joint is (av. ult. str. of joint)/(av. ult. str. of reinforcing tape) = (560 lb)/(570 lb) = 98%.

2. Joint efficiency is within predicted values and is acceptable for application intended.

GENERAL REMARKS

TESTED BY	DATE COMPLETED

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED	PROJECT NO. E-0067
Tape, radial, w/reinforcing member.	TEST NO. E-0067-TL/9

PURPOSE [x] ULTIMATE STRENGTH [x] POINT OF FAILURE [x] EFFICIENCY [ ] OTHER

TEST METHOD Same as Federal Specification CCC-T-191b, Method 4102, except fabricate and pull 3 samples per attached sketch. Use Tinius Olsen testing machine, 2400-lb range, with 12-in./min. load rate, and 3 in. split drums.

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB		JPB	

TABLE

Sample	Ult. strength, lb
1	572
2	568
3	572
Av.	570

COMMENTS

1. Radial tape failed at point indicated on sketch.

2. Dacron tape spec 66-5 Type II, control samples were from roll #601 (av. ult. strength of 3 control samples was 570 lb).

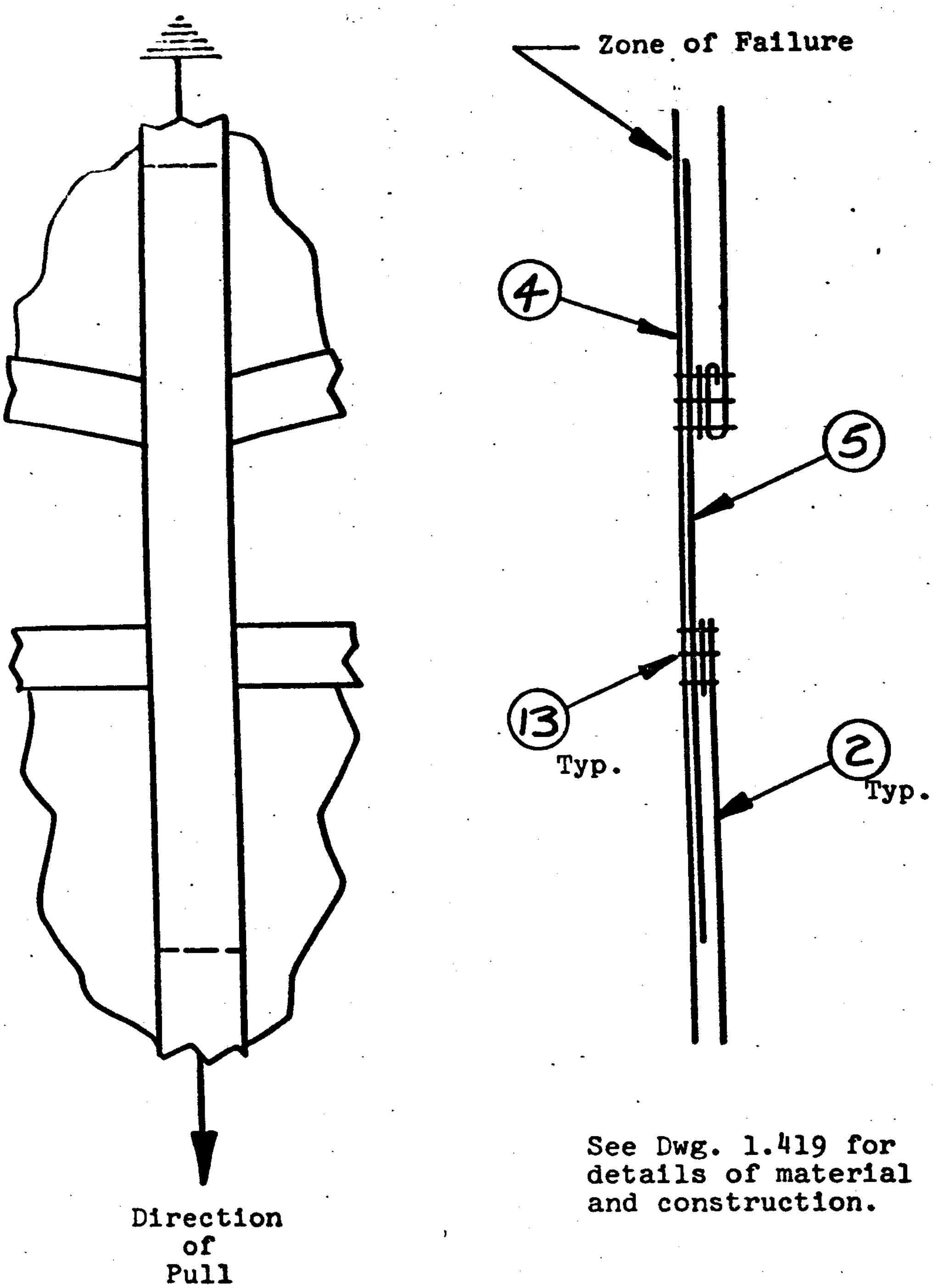
RESULTS AND CONCLUSIONS

1. All test samples failed at point indicated on attached sketch, which would indicate that the radial tape shown in Detail E of dwg. 1.419 is 100% efficient.

2. Joint efficiency is within predicted values and is acceptable.

GENERAL REMARKS

TESTED BY	DATE COMPLETED



Radial Tape with Reinforcing Member
Sketch E-0067-TL/9

LABORATORY TEST REQUEST/REPORT

ITEM(S) TO BE TESTED	PROJECT NO. E-0067
Band, vent.	TEST NO. E-0067-TL/10

PURPOSE [x] ULTIMATE STRENGTH [ ] POINT OF FAILURE [x] EFFICIENCY [ ] OTHER

TEST METHOD Use Tinius Olsen testing machine, 2400-lb range, with 12 in/min load rate. Test similar to Federal Spec. CCC-T-191b, Method 4102, except fabricate and pull one sample per attached sketch. Use 3 in. split drums.

REQUESTED BY	DATE REQUESTED	REQUEST APPD. BY	DATE APPROVED
JPB	6/9/67	JPB	6/9/67

TABLE

Sample	Ult. strength, lb
1	1682

COMMENTS

Dacron tape spec 66-5, Type II, control sample ult. strength (average of 3) = 573 lb.

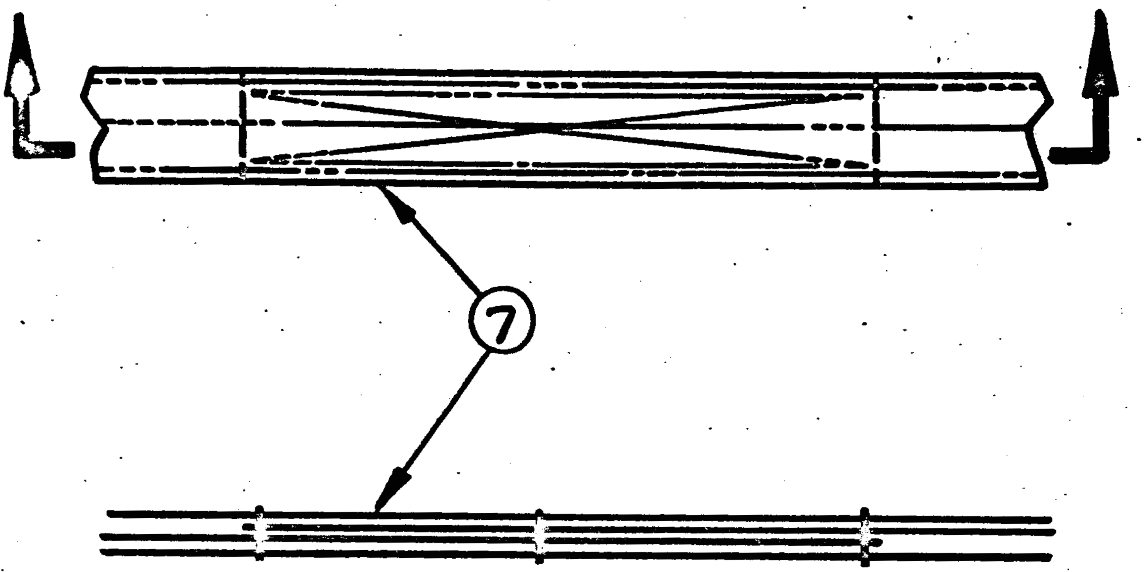
RESULTS

1. Efficiency of joint is (av. ult. str. of joint)/(av. ult. str. of reinforcing tape) = (1682 lb)/(573x3) = (1682 lb)/(1719 lb) = 98%.

2. Ultimate strength of hem is within predicted value and is acceptable.

CONCLUSIONS

TESTED BY J. P. Brecht	DATE COMPLETED 6/9/67



(ref. Pion. Dwg. No. 1.419 GR-1.)

Band, Vent
Sketch E-0067-TL/10